POWER PLANT ENGINEERING

Established Over 29 Years

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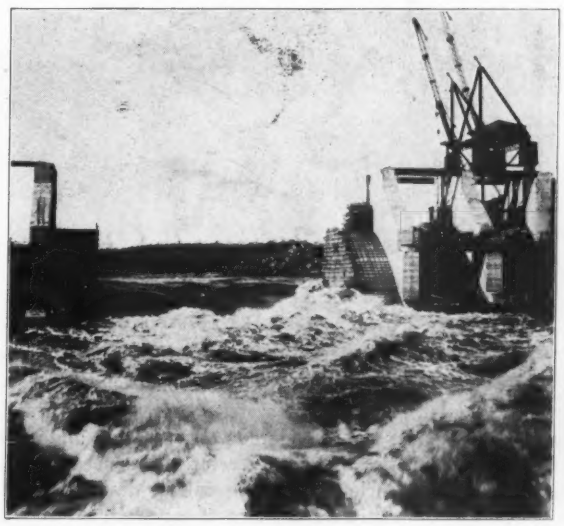


White Coal, 625 T. a Second

THIS UNUSUAL picture shows white coal, as someone has fancifully termed water in motion, thundering through an opening in an unfinished spillway at a rate of about 625 T., or 20,000 cu. ft., a second. This spillway, with a maximum discharge capacity of 225,000 cu. ft., is one of four that are nearing completion in the Grand Discharge, where enough white coal to generate 540,000 hp. will be stored up. The Grand Discharge leads from Lake St. John, about 100 mi. north of Quebec, Canada, into the Saguenay River. At this point, on an island called Isle Maligne, a hydro-electric plant is being constructed, said to be the largest single installation of hydraulic power equipment in the world.

Owing to the isolated position of this plant, the work of construction had to be planned with extreme care. The construction camp was laid out for maximum convenience of the workmen and maximum efficiency in following the work schedules that were prepared. Almost as much work was done in designing the construction equipment as in designing the plant itself, but the final result demonstrated that the pains were well taken. More complete details of this work, together with some interesting views of the construction work, are given elsewhere in this issue.

Valmont Station Now in Service

NEW DEVELOPMENT OF PUBLIC SERVICE CO. OF COLORADO LOCATED ON ARTIFICIAL LAKE NEAR DENVER. BY R. R. THRONE

CONSTRUCTION having been completed on the Valmont Station, it has become one of several plants serving the system covered by the Public Service Co. of Colorado. Its location and other characteristics are therefore influenced by this relationship, so a brief description will be desirable. The city of Denver constitutes the largest concentrated load of the system. The load demand, however, of the district to the north throws the load center of the system to the northwest of Denver about 6 mi.

Load growth in the districts served demanded further capacity. No expansion of the present steam plants could be considered because of the lack of sufficient circulating water. An investigation of all possible water power sites within 150 mi. of Denver showed that there were none which were feasible of commercial development. There are no rivers in the district served which provide sufficient annual flow for condenser circulating water. The Platte River, the only stream worthy of considering, cannot provide for over 25,000 kw. capacity without recirculation. A stream flow plant then could not be considered. To consider a plant operating on either a spray pond or a cooling tower also involves the problem of supplying makeup water for the radiation and cooling losses and operating at higher pumping heads.

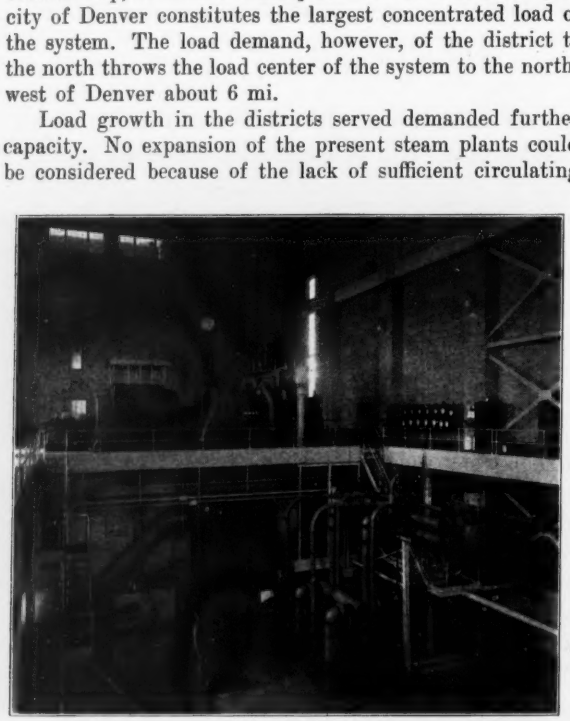


FIG. 1. NEUTRAL OF THIS 25,000-KV.A. GENERATOR IS NOT GROUNDED

Make-up water required for condensing purposes in any closed circulation system is a large quantity in a year. This is a consumption use of water and would require a steady diversion from the streams. The direct stream flow during many months of the year is already over appropriated for irrigation use. Colorado streams have a peculiar annual flow curve, that is the flow is low for 10 mo. of the year and the greater quantity of water comes down in a big wave during May and June at which time the snow on the higher mountains melts. It thus becomes a problem of skimming the crest of the peak wave and thereby obtaining and placing in storage enough water to run the plant through the year. Since a reservoir is thus required in any event there would be no advantage and several disadvantages in going to a spray pond or cooling tower system.

Study was made to determine the heat radiating capacity of an acre of water and the losses due to natural and forced evaporation. These figures determined the area and water content of the desired reservoir. Inasmuch as the waters of the Platte River may be entirely diverted for the use of the city of Denver, other streams were investigated. It was finally decided to eliminate the pumping head and depend on the radiation of a natural lake to reduce the

condensing water temperature. A lake would then be required such that expansion for larger capacities could take place as well as to provide for sufficient storage waters to carry over the periods when no water is available.

Site Selected at Valmont

Out of a large number of lakes considered within the load district, the site near Valmont was selected. This site which is 26 mi. north of Denver permits ready access to the coal fields of northern Colorado over two railroad systems. The subsoil also furnished a good reservoir site from the standpoint of seepage. The topography is such that the present lake of 120 acres area can be increased to 540 acres area of 11,162 acre feet capacity. This area is sufficient to care for an ultimate development of 200,000 kw. on the basis of 400 kw. per acre. This figure is felt to be conservative. This site is located within a short distance of the South Boulder and Middle Boulder Creeks, so that supply ditches need not be of any great length.

Water storage of Valmont duplicates the capacity of the Nederland reservoir in Boulder Canyon on the same water shed. This latter reservoir was installed in connection with the Boulder Canyon hydro-electric development. This water is all released by the hydro plant in the winter time when the farmers do not need it and can then be used to fill the Valmont Reservoir. Water can also be released from the Valmont reservoir in the summer time to satisfy irrigation requirements thus allowing water to be held in the Nederland reservoir until the following winter.

It is not always a desirable move to locate a plant at the mine mouth. The production of coal from the northern Colorado lignite fields is primarily to provide for a domestic demand. This demand is highest during winter and low during the warmer months. Lignite coal is soft, breaking up readily, therefore each 2 T. of mine-run coal hoisted produces 1 T. of slack and 1 T. of marketable coal. It was much better in this case to have the plant so located that the greatest advantage could be taken of surplus slack from the many mines operating. Water is plentiful during the summer months at the hydro-electric plant. The system load is less in summer than in winter, therefore, generation with steam is carried on at a low load factor in the summer. The demand for generating coal follows the demand for domestic coal with the result that only a small percentage of mine-run coal need be considered and that only during the warmer months when much less coal is being burned.

FIG. 3. EACH FURNACE PROVIDES A COMBUSTION SPACE OF 10,288 CU. FT.

Incidentally in constructing this plant it was built on dry land and later the water was allowed to flow around it. This was done by draining the lake during the construction of the intake structures, thereby eliminating all under water work. The intake structures for five units were built because it will never again be possible to drain the lake for similar purposes.

Circulating Water Follows 3 Mi. Course

Circulating water is drawn from the bottom of the lake or reservoir and after passing through the condensers is discharged into a tunnel which now discharges back to the lake at the west end of the plant. In order to better disperse this discharge water over a wide area a pier has been built extending out into the lake. This plan will care for three of the ultimate 10 generating units. Later when the reservoir is enlarged to care for 10 units the circulating water will discharge across the peninsula, thereby

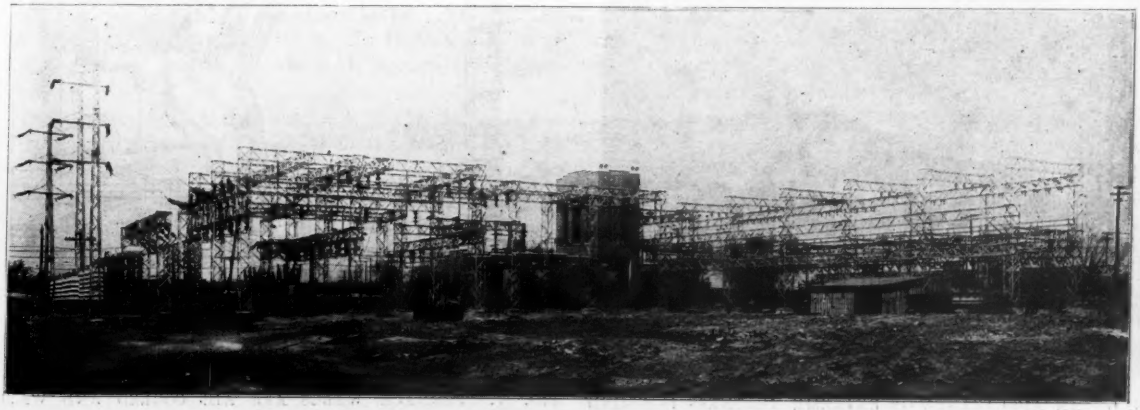


FIG. 2. DENVER TERMINAL, SHOWING THE 13-KV. BAY

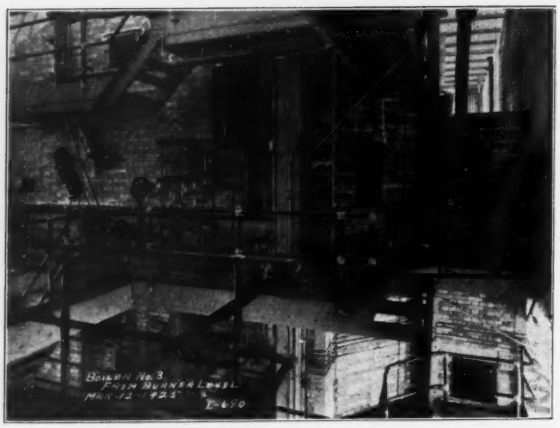


FIG. 4. PLATFORMS ARE ARRANGED AROUND THE SETTINGS FOR THE CONVENIENCE OF THE OPERATORS

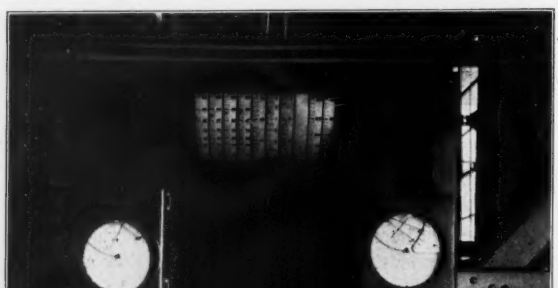


FIG. 5. CONTROLS AND INSTRUMENTS FOR EACH BOILER ARE BROUGHT TO ONE BOARD

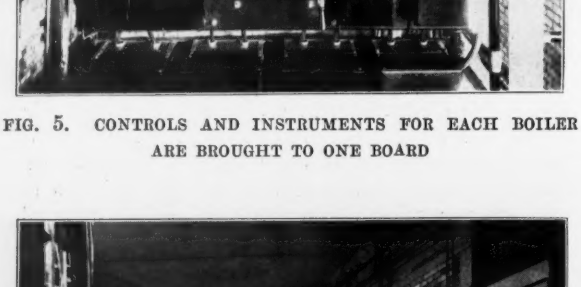


FIG. 6. AN APPEARANCE OF EXTREME NEATNESS IS FOUND THROUGHOUT THE STATION

requiring a path of about 3 mi. to be followed before again arriving in the plant.

Provision for such a development will require the building of several earthen dams. The largest of these will be 3400 ft. long, 90 ft. high and 370 ft. wide at the base. A drainage scheme will be employed to prevent slippage of the dam, a fault so common in this type of construction. Adjoining buttes and ridges otherwise afford a natural reservoir.

TYPICAL ANALYSES OF THE COAL USED AT VALMONT

Mine	Columbine	Puritan	Monarch	Simpson
B.t.u., dry basis	12,500	12,575	11,870	12,428
Moisture	21.66	25.74	19.25	28.58
Volatile	31.84	31.87	33.28	32.79
Fixed carbon	41.97	38.71	40.74	42.54
Ash	4.53	3.68	6.73	4.09
B.t.u., per pound	9793	9340	9587	9872
Sulphur	0.26	0.38	0.31	0.75
B.t.u., dry basis	12,500	12,575	11,870	12.428
B.t.u. on moist and ashless basis	13,300	13,280	12,990	13,195

Choice of fuel burning equipment was based upon, first, the ability to burn Colorado lignite and second, the ability to pick up sudden increases in load often ranging from floating load to full generation capacity. Experiences with every other type of fuel burning equipment from hand-fired grates to the most recent underfeeds and forced draft chain grates proved that Colorado lignite coal cannot be burned with low ash pit losses and realize above normal boiler ratings. Underfeed stokers proved their capability to accelerate at the rate of 100 per cent per minute but their operation was at the sacrifice of operating economy. Although requiring a higher initial investment, after properly weighing all considerations, pulverized fuel burn-

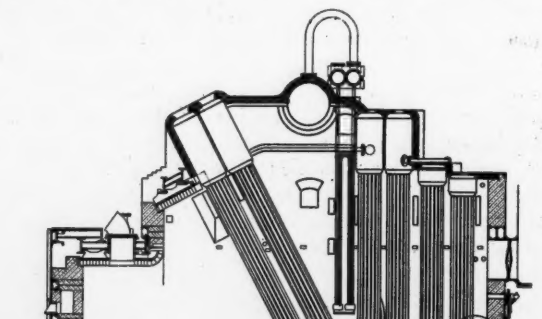


FIG. 7. FURNACE WALLS ARE AIR COOLED AND WATER SCREEN PROTECTS FURNACE FLOOR

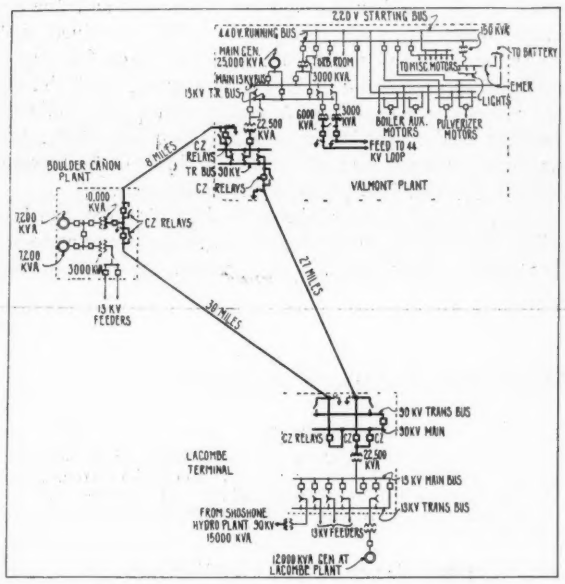


FIG. 8. SIMPLIFIED DIAGRAM OF THE VALMONT STATION AND THE 90-KV. LOOP

ing equipment was selected for the boiler room. In the turbine room the turbine-bleeding, feed-heating cycle was employed.

Clam-Shell Bucket Used to Elevate Coal

Coal cars arriving at the plant are spotted over a concrete-receiving pit. Should the car not be equipped with dump bottoms, the clam-shell coal unloading crane on top of the preparation house will unload the car direct. Otherwise coal will be dumped into the pit and the clam shell will elevate it and discharge it into a receiving hopper mounted on the tower. This hopper is located over a short belt conveyor equipped with a magnetic roll which removes all tramp iron as the coal is fed to the two-drum crusher. Slack coal so sized then falls to a 650-T. storage bin inside the preparation house. Four flue-gas type dryers are bolted onto the bottom of the storage bin, each provided with coal gates to allow the emptying a dryer. Gases for these dryers are taken from the base of the radial-brick stack and after passing through the dryers and the dryer fan are discharged through separate stub stacks through the roof. The mills take coal directly from the dryers. After having been ground it is elevated to the cyclones located at the top of the preparation house. Motor driven fans provide the circulating air for the regulation of fineness of the coal and to elevate the prepared coal to the cyclones.

Installation work in connection with the dryers is not yet completed, the coals indicated in the table have been burned in powdered form without having been dried. The moisture content is chiefly chemically combined, even though the coal may be powder dry and dusty upon arrival, yet the moisture content will be about 20 per cent. This moisture may be likened unto that embodied in rock salt, a large percentage of the weight of which is water of crystallization. The division of surface and inherent moisture bears an important relationship in the design and operation of pulverized fuel preparation and burning equipment. Under these conditions normal mill capacities of 6 T. per hr. have been increased to monthly averages of

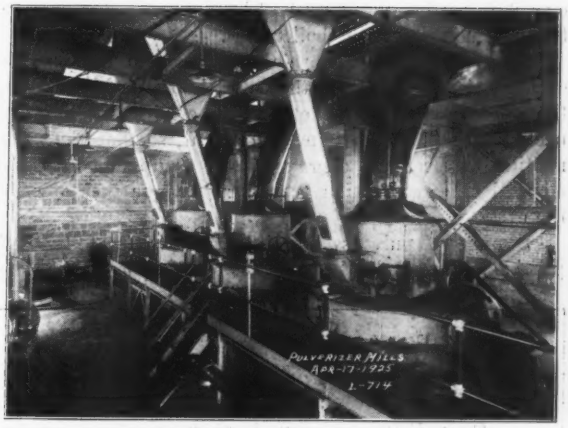


FIG. 9. COAL PREPARATION HOUSE IS PROVIDED WITH A STORAGE BIN OF 650-T. CAPACITY

FIG. 10. MOTOR DRIVEN FANS PROVIDE AIR FOR COAL FINENESS REGULATION AND DELIVERY TO THE CYCLONES

FIG. 11. COAL IS FIRED THROUGH THE FURNACE ROOF. THE FANTAIL BURNERS ARE SET VERTICALLY

over 8 T. per hr. requiring 15.9 kw-hr. per T. for preparation and delivery to the boiler bins.

Screw conveyors remove the powdered coal from the cyclones and deliver it to the boiler bins. Both conveyors, the one relaying to the other, are electrically interconnected with the pulverizing equipment, so that the interruption to electrical energy of any equipment will also stop all other equipment furnishing coal farther down in the cycle.

Storage of pulverized coal to the extent of 40 T. is provided above each of the 13,320-sq. ft. Bigelow-Hornsby boilers. Four duplex feeders mounted on the bottom of each of the four bins deliver coal to the eight fantail burners provided on each boiler. At the discharge of each feeder screw, primary air at a pressure of 16 to 20 in. of water is admitted.

Rate of feeding coal is under control of variable—speed, direct-current motors. The controls are so arranged that all feeders can be varied in unison or any particular feeder adjusted separately. This feeder control is located on the boiler-control panel together with instruments recording and indicating the boiler performance. Gages provided for this purpose consist of one boiler meter recording the steam output, air flow through the boiler unit and flue gas temperature; one steam-pressure recorder combined with one steam-temperature recorder such that when full superheat of 200 deg. exists at normal pressure of 375 lb., the two records will combine. A multipointer gage indicates the four feeder speeds, furnace draft, uptake draft, primary-air pressure and the rate of flow of feed water through the two feed pipes to the boiler unit.

Coal is fired through the roof of the furnace, the fantail burners being set vertically and at right angles to the front wall. Secondary air is admitted into the furnace through 96 openings, each 7 by 9 in. in size. These openings are arranged in six zones, each zone receiving air under a spring controlled damper which is set in the sidewalls, and also in the rear of the bridgewall. The boilers are set so as to provide a furnace height of 28 ft. 8 in. from the ashpit to the burner and 23 ft. 9 in. from the water section to the burner. The furnace inside width is 22 ft. and the depth is 16 ft. This allows a gross furnace volume of 10,288 cu. ft. and net volume of 8160 cu. ft.

Boiler settings are built up of fire brick embodying hollow side walls which are tied back by means of block tile to extension steelwork serving as buckstays. The in-

Principal Equipment Installed at the Valmont Station

Coal Handling and Preparation Equipment

One traveling unloading tower built by the Main Electric Co. equipped with 3-yd. bucket, magnetic separator having 24 in. by 36 in. pulley driven by a 3-hp. motor and one coal crusher.

Four wood driers, 144 sq. ft. active drying surface furnished by Combustion Engineering Co.

Two Sturtevant drier exhausters, each 35,000-c.f.m. capacity at 5300 ft. elevation and 150 deg. F. at 5.5 in. head driven by two Westinghouse a.c., 440-v., 3-phase, 60-hp., 600-r.p.m. motors.

Four Raymond, 6-roll pulverizers equipped with Raymond air separation system. Mills direct-driven by Westinghouse 100-hp., 450-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motors. Sturtevant fans as exhausters direct driven by Westinghouse, 50-hp., 1200-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motors.

One 14-in. screw conveyor, 242 ft. long, delivery 38 T. per hr. of powdered coal to boiler bins. Driven by one Westinghouse 30-hp., 900-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motor through chain and spur gearing.

Fuel Burning Equipment

Sixteen special duplex feeders, 5-in. air inlet, driven by 16 variable-speed, 3-hp., 300- to 900-r.p.m., d.c. motors.

Four Sturtevant special steel-pressure blowers No. 8, 6400-c.f.m. at 15-in. water head and 200 deg. F. and 5300 ft. altitude. Each driven by Westinghouse 50-hp., 1800-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motors.

32 Lopulco fantail burners, size 4 in.
Arches, M. H. Detrick Co.
Firebrick, Walsh Fire Clay Products Co.

Boilers, Superheaters and Tube Screens

Four, unit-drum type Bigelow-Hornsby boilers of 10,730 sq. ft. boiler heating surface and 2590 sq. ft. of economizer heating surface to operate at 375 lb. ga. pressure.

Four convection-type Foster superheaters of the double-deck type composed of 6288 sq. ft. surface, each to furnish steam superheated 200 deg. F.

Four tube screens composed of 18, 4-in. tubes totaling 302 sq. ft. active heating surface.

Safety Valves, Consolidated.

Stack

One radial-brick stack, 24 ft. inside diameter at bottom and 16 ft. diameter at top. Height above the burners, 331 ft. Equipped with outside ladder and testing stations. Built by the Alphons Custodis Chimney Construction Co.

Feed Water Pumps and Heaters

Two 6-in. Worthington-Jeansville, centrifugal, boiler-feed pumps, horizontally-split case, 1000-g.p.m., each, driven by Westinghouse 360-hp. steam turbine at 1900-r.p.m.

Two 6-in. Allis-Chalmers, general-service, centrifugal pumps, type S, 1000-g.p.m., 110-ft. head, driven by Westinghouse 50-hp., 1750-r.p.m., 60 cycle, 3-phase, 440-v., a.c. motors.

One Elliott feed-water heater, 1200 sq. ft. surface, 4 water passes for use at 200 deg. F. bleeder point. One Elliott feed-water heater, 242-sq. ft. surface, 2 water passes for use at 200 deg. F. bleeder point. One Elliott feed-water heater, 825-sq. ft. surface, 4 water passes.

One Elliott feed-water deaerator heater, operating at atmospheric pressure with capacity of 320,000 lb. per hr. Two 2-in. Allis-Chalmers, heater-drainage, centrifugal pumps, type HS, 75-g.p.m., 122-ft. head, driven by Westinghouse 10-hp., 1750-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motors.

Turbo Generator, Condenser and Auxiliaries

One Westinghouse, parallel-flow, Bauman-type turbine, 350-lb., 200 deg. superheat, abs. back pressure, 1800-r.p.m., equipped for four-stage bleeding. Direct connected to one Westinghouse 25,000-k.v.a., 1800-r.p.m., 60-cycle, 3-phase, 13,800-v., 4-pole generator. One Westinghouse 125-kw., 1800-r.p.m., 500-amp., 250-v. shaft exciter.

One Westinghouse surface condenser, two pass, radial flow, 30,000 sq. ft. supported on spring bases.

Two Westinghouse circulating pumps, 18,000-g.p.m., at 25-ft. total head, each driven by Westinghouse 150-hp., 490-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motors.

One Westinghouse steam turbo-gear coupled through Cutler-Hammer magnetic clutch as a duel drive to one of the above circulating pumps. Turbine is rated at 175-hp., 3700-r.p.m., 350-lb. pressure, 200 deg. superheat and 1-lb. back pressure. Gear reduction, 3700 to 527.

ner wall is 9 in. thick and the outer wall varies from 13½ in. thick to 9 in. thick leaving an air space which varies from 14 in. to 18½ in. wide. Hydraulically-operated ash gates discharge ash from the pits to the sluiceway. Combustion ashes settling out in the rear part of the boiler are washed out to the ash sluiceway below.

Integral Economizers Installed

Each boiler consists of 13,320 sq. ft. heating surface of which 10,730 sq. ft. is allocated to the boiler section and 2590 sq. ft. to the integral economizers. Boiler sections are arranged in rows containing the following number of units—9—9—7—5—5. This arrangement tends to maintain a uniform gas velocity through the boiler unit. Steam is superheated in Foster superheaters of 6288 sq. ft. area each.

Boilers are supplied with feed water from either or both of two feed lines. This water is admitted into each end of a header serving each boiler from which five 2-in. supplying pipes deliver water to the economizer sections. Feed water enters this header through feed water regulating valves.

Each of the four boilers discharges steam into one main steam header serving the main turbine unit. Before entering the turbine room an anchored cross is provided from which steam for auxiliary use is taken. The other side of this cross will provide a connection to the future boiler units. A system of header drainage has been used which also serves as a portion of the auxiliary steam header. This arrangement allows the operation of auxiliary equipment by any one boiler should it become necessary.

At present one 20,000-kw. turbine generator is under load. This turbine is a 25,000-kv.a. Westinghouse-Bauman type of turbine and is connected to a 30,000-sq. ft. surface condenser. Building space will allow the installation of a second unit before it will be necessary to extend the plant buildings. Steam is bled from three of the four points provided to heat the feed water up to 300 deg. F. As the plant must carry loads which fluctuate rapidly, the open feed water system is provided. Surge tanks are provided so that storage can be taken or used at times of sudden load changes. Condensate is pumped directly from the condenser hot well to the high level surge tank. This tank also receives all make-up water and all other condensate which may have been used for cooling purposes or collected as drips. Water as required by the boiler room flows

Principal Equipment Installed at the Valmont Station

One Westinghouse Leblanc air pump, capacity 11.93 cu. ft. of 70 deg. free dry air per minute at 28.5-in. vacuum, driven by Westinghouse 50-hp., 690-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motor.

One duplex steam air ejector, capacity of 19.22 cu. ft. free air per minute at 70 deg. Equipped with surface type inter and after condensers.

Two Westinghouse condensate pumps, capacity 300,000-lb. per hour at 100-ft. total head. One driven by Westinghouse 40-hp., 1750-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motor. Other driven by Westinghouse steam turbine. 60-hp. at 350-lb. pressure, 200 deg. superheat, 1-lb. back pressure.

Miscellaneous Mechanical Equipment

Two 6-in. Allis-Chalmers, type S, centrifugal, house-service pumps, 1000-g.p.m. at 110-ft. head driven by Westinghouse 50-hp., 1750-r.p.m., 60-cycle, 3-phase, 440-v., a.c. motors.

One pneumatic sweeping system furnished by Allen & Billmyre Co.

One passenger and one freight elevator by Otis Elevator Co.

One straight-suspended, coal, test-weigh hopper scale, capacity 6000-lb. by R. J. Shields.

Eight Copes boiler feed-water regulators, size 4-in., type B. I.

Four Edwards non-return valves, size 8-in. Steam header valves by Chapman Valve Mfg. Co. Flange joints tongue and groove. Gaskets, annealed copper.

One 5-in. ash-sluicing pump, 750-g.p.m. at 50-ft. head, 900-r.p.m.

Electrical Equipment

Four transformers, 7500-kv.a., single-phase, oil-insulated, water-cooled, 90,000- to 13,800-v. Three transformers, 2000-kv.a., single-phase, oil-insulated, water-cooled, 46,170- to 13,800-v. Three transformers, 1000-kv.a., single-phase, indoor-type, oil-insulated, water-cooled, 13,800- to 460,230-v., for station power. One transformer, 150-kv.a., single-phase, indoor-type, 440 to 115-230-v., for station lighting.

One battery charging motor-generator set, 100-kw., 250-v., d.c. generator, driven by 150-hp., 440-v., 3-phase, 60-cycle induction motor.

One Westinghouse storage battery, 387 amp. hr., 400 amp. for 15 min., with final voltage of 1.65-v. per cell.

One Westinghouse storage battery with maximum rating for one minute of 400 amp. For operation of oil circuit breakers and accessories.

One motor-generator set, 4½-kw., 175-v., d.c. generator, driven by 7.5-hp., 440-v., 3-phase, 60-cycle, a.c. motor.

One five-section circular control desk. One five-panel, black-marine finished slate auxiliary switchboard. One seven-panel field, battery and lighting switchboard.

Two lightning arresters, auto-valve type, 110,000-v., 3-phase. Two lightning arresters, auto-valve type, 50,000-v., 3-phase.

Six suspension choke coils, 200 amp., type D16, 110-kv. service. Six choke coils, 200 amp., 50-kv. service.

Six 400-amp., 50,000-v., type RA, single-pole, single-throw, outdoor, disconnecting switches, inverted mounting. Fourteen disconnecting switches, 50,000-v., type RA. Twelve disconnecting switches, 115,000-v., type RA, 400 amp. Six disconnecting switches, 15,000-v., type R, 400 amp. Six hand-operated disconnect switches, 400 amp., 3-pole, 115-kv., type R. Three disconnect switches, 1200-amp., single-pole, single-throw, 15,000-v., type R. One disconnect switch, single-pole, 73,000-v., type RA for transformer. Twenty-one disconnecting switches, 1200-amp., single-pole, single-throw, 15,000-v., type S. Thirty-three disconnecting switches, 400-amp., single-pole, single-throw, 15,000-v., type S.

Six oil circuit breakers, type 62, 400-amp., 115,000-v., 3-pole, single-throw, outdoor, solenoid, operated with bushing type transformers. Three oil circuit breakers, 200-amp., 15,000-v., 3-pole, single-throw, solenoid-operated, type "CO22." Four oil circuit breakers, 600-amp., 15,000-v., 3-pole, single-throw, solenoid-operated, type "CO22."

Transmission Line

Ninety-eight suspension, double-circuit steel towers. Thirty-two strain, double-circuit steel towers. Twenty-four suspension, single-circuit steel towers. Twenty-six strain, single-circuit steel towers. Nine 65-ft., steel-latticed poles, double-circuit. Forty-nine 55-ft., steel-latticed poles, double-circuit. All furnished by The American Bridge Co.

Ninety-nine mi., steel-core, aluminum cable by Aluminum Co. of America. Twenty mi. of No. 00, hand-drawn, bare-copper wire by Anaconda Copper Co. Insulators, clamps and hardware by Ohio Brass Co.

from this tank and passes first through the air ejectors and then through the 140-deg. bleed heater and the 200-deg. bleed heater. The 200-deg. heater serves as a regulating heater under the control of a thermostatic regulator so that the outlet temperature when combined with the amount of steam available in the deaerator will maintain a uniform temperature of 206 deg. F. at this point. This temperature is taken as the controlling temperature for proper deaeration of the feed water.

Boiler feed pumps draw upon the storage of deaerated water in the deaerator and pump through the 55-lb. bleed heater and then to the boiler units. Feed pumps are steam driven, while all other auxiliary equipment is normally electrically driven.

Circulating water equipment consists of two centrifugal pumps, one motor driven, the other duplex driven by both steam turbine and motor. Each pump is rated at 18,000 g.p.m. at 490 r.p.m. Condensate is removed by either of two centrifugal pumps, one of which is motor driven, the other steam turbo driven. Air removal equipment consists of a motor driven Le Blanc air pump and also a duplex bank of steam air pumps. The normal plant operation consists of all motor driven auxiliaries except the feed pumps, yet the steam driven equipment is sufficient to permit operation should system disturbances affect the station source of supply when the main turbine unit is out of service.

Some effort has been made to insure a steady flow of energy from the plant as the following notation will show. Two railroads serving many miles supply the plant. The plant has a locomotive crane with a boom sufficiently long to permit it to place coal in the main bunker of the preparation house in the event that the main crane breaks down. There are four pulverizing mills, duplicate coal conveyors, multiple-feeder units on each boiler. One of the primary air fans on the pulverized coal feeders has been equipped with dual drive. Four boilers allow for plenty of capacity with one out for repairs. Feed pumps, circulating water pumps, condensate pumps and exciters are all in duplicate. The plant is connected to two loop circuits, the 100-kv. loop transmission serving Denver and the 44-kv. loop transmission serving the several cities of northern Colorado.

This plant is particularly fortunate in having a good supply of makeup water for boiler feed. A connection for this purpose was made to the mains of the city of Boulder. This community obtains its water from a melting glacier and diversion is made before the water has passed over anything more than granite rock. This accounts for the absence of evaporators or feed water treating systems.

Generation is at 13,800-v., 3-phase, 60-cycle, the generator being star connected. The neutral of the generator is not grounded. The 13,800-v. switching equipment is located in a switch house at the end of the turbine hall. All incoming and outgoing leads enter the switch house through the first floor and consist of single conductor, varnished-cambric, insulated cables in fibre duct cast in concrete slabs. The outgoing leads and control circuits for the outdoor equipment leave the switch house through a cable tunnel built above grade through the outdoor switch yard.

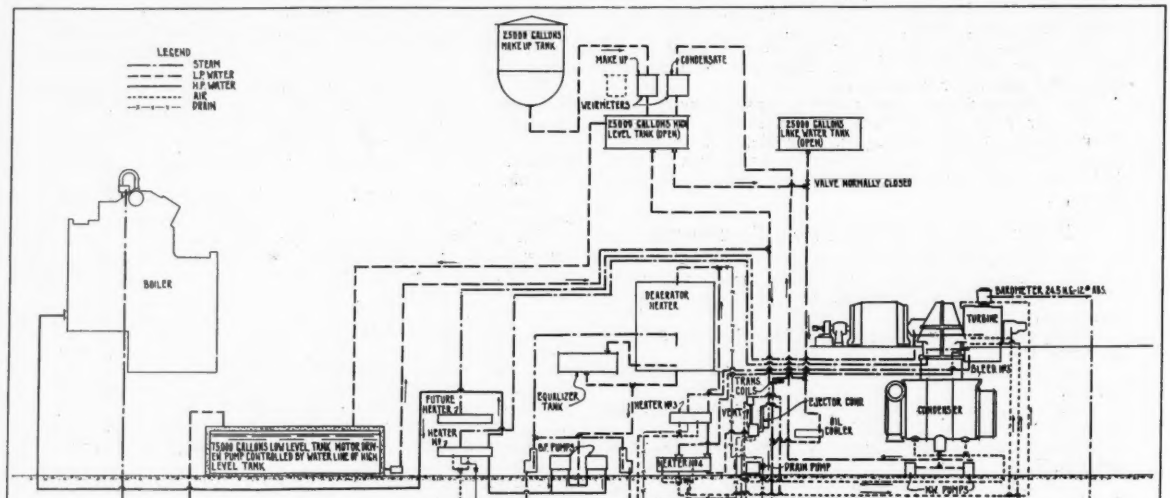


FIG. 12. HEAT BALANCE DIAGRAM OF THE VALMONT STATION, PUBLIC SERVICE CO. OF COLORADO

Conventional grouped phase arrangement of the main and synchronizing bus was used. Both busses are located on the third floor of the switch house. Three pole, 25,000-v., Westinghouse type CO22, oil-circuit breakers are used for all 13-kv. switching. At present no load limiting or synchromizing reactors are installed, but space has been provided for them in the first floor of the switch house.

Excitation Available from Four Sources

Excitation for the main unit may be supplied from either the direct connected exciter, a steam turbine driven exciter, or in emergencies from a 35-kw. motor-generator set and storage battery in parallel. Automatic voltage regulation is obtained by the use of a rheostatic-voltage regulator, operating in series with the main field. This allows a constant voltage to be maintained on the exciter bus and while it is somewhat slower than the contact making regulator operating on the exciter field, it is less sensitive to system disturbances and is believed to be more reliable. The bench type switchboard is located on the fifth floor of the switch house. From this board are con-

trolled the generator, the 13-kv. breakers and the outdoor 44 and 90-kv. oil switches. Private telephone lines to the system, Bell and inter-communicating telephones for the station and the turbine room signal system terminate in the control room. The control and signal conduits terminate in a "half floor" immediately below the control room. Access to this space is provided through a conduit shaft extending the full height of the switch house.

House power is supplied from a bank of three 1000-kv.a. transformers, located on the ground floor. This bank is large enough to carry the entire station load operating open delta. The transformers step down from 13,800 v. to 440 and 220 v. The 220-v. connection supplies a starting bus only. All station auxiliary motors, including coal preparation and handling machinery, with the exception of the boiler feeder motors, are supplied from this bank, at 440 v., three phase. Station lights are supplied through a 440/220-110-v. single-phase transformer. The boiler feeders are driven by 220-v., single-phase current.

Direct current for charging is normally obtained from a 35-kw. motor-generator set, but may be supplied by the turbine-driven exciter. Station lights are automatically thrown on the battery in the event of failure of house power. All auxiliary motors are push-button controlled and are provided with "stay put" starting buttons, so the motors will be automatically restarted after an interruption of the house power supply. The control board for the station auxiliaries is located in the turbine hall on the ground floor, just below the main turbine deck.

Energy is distributed from the station through an outdoor transformer and switching substation at 44,000 and 90,000 v., three-phase. The two 44-kv. lines form a loop circuit approximately 125 mi. in circumference, which supplies energy to nine substations in cities and towns of northern Colorado. These lines are supplied through one 3000-kv.a. and one 6000-kv.a., 13,800/44,000-v. transformer bank. The transformers are star connected on the 44-kv. side, and are operated with the neutral solidly grounded.

The 90-kv. bus is supplied through one 22,500-kv.a. transformer bank, also star connected on the high tension side and with the neutral solidly grounded. Two outgoing 90-kv. lines are in service, one of which, 28 mi. long, connects the Valmont plant directly with the terminal substation two miles inside the limits of the city of Denver. The line inside of Denver was built on a private right of way purchased outright and standard country towers were used except for one block. The other line, 8 mi. long, connects Valmont with the Boulder Canyon hydro plant, which is also connected to the Denver terminal by a 30-mi., 90-kv. line. Westinghouse autovalve arresters are provided for both the 44-kv. and the 90-kv. lines.

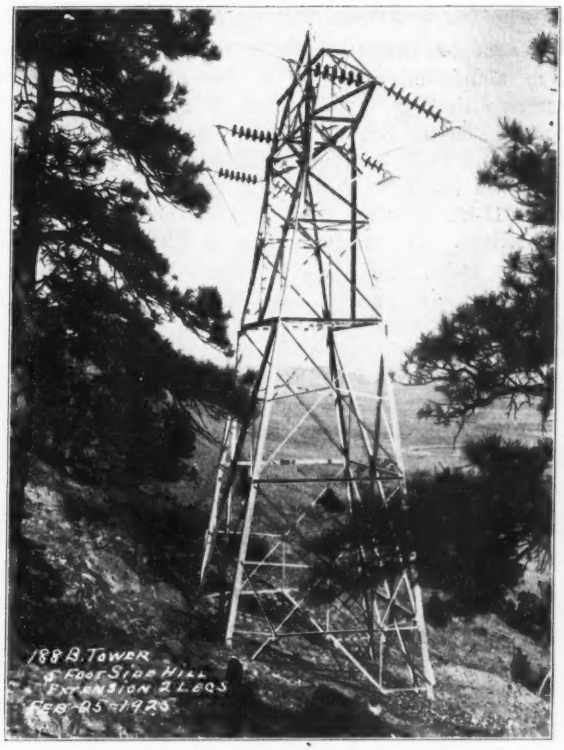


FIG. 13. DEAD-END TOWER IN BOULDER CANYON

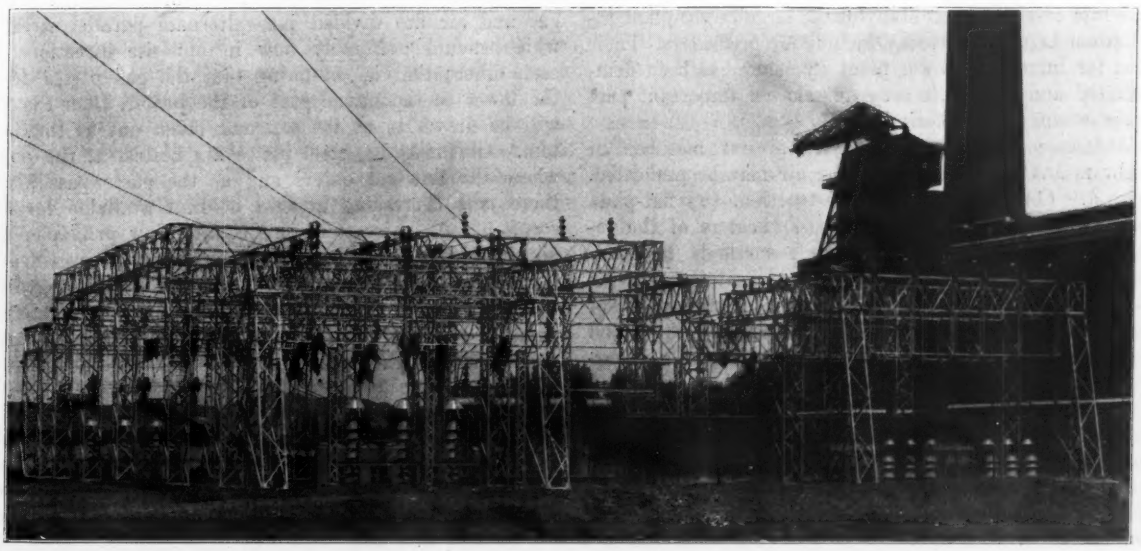


FIG. 14. OUTDOOR SUBSTATION AT THE VALMONT PLANT, SHOWING 90-KV. AND 44-KV. BUS STRUCTURE

Maximum Span Is 2200 Ft.

Valmont-Denver transmission line consists of 336,000 c. m. aluminum cable, steel reinforced on double-circuit towers, with 12-ft. vertical spacing. The same conductor was used on the Boulder Canyon line, with single-circuit towers and 14-ft. horizontal spacing. Seven 10-in., Ohio, brass-disk insulators are used in suspension strings and seven 11-in. disks are used in dead end and semi-dead end strings. The maximum span is 2200 ft. long.

The 44-kv. lines leave the station on double-circuit steel poles with pin-type insulators. The double-circuit line is approximately 3 mi. long, then the circuits separate and are carried on wood poles to form the loop previously described. The Denver terminal substation was located adjacent to a steam generating plant owned by the company. An outdoor terminal substation was built and the 90-kv. switching equipment and transformers installed. One 22,500-kv.a. transformer bank steps down from 90-kv. to 13,800 v. for transmission to city substations. The terminal substation is also the load despatching center of the system.

Lines from Valmont to Denver and from Boulder Canyon to Denver follow separate rights of way. It was desirable that these circuits be operated as loop, to prevent failure of either line from affecting the supply of power to Denver. Satisfactory relaying of this loop offered some difficulties, as generating equipment is located at the three sectionalizing points of the loop. Westinghouse relays have been installed for both line to line and line to ground faults. These relays require a source of potential which will be proportional to the line voltage, during a disturbance. The expense of 90-kv. potential transformers would have been prohibitive, so the potential coils of the relays are supplied through compensators, from potential transformers on the low-tension side of the 90-kv. banks. The compensators are arranged to compensate the voltage impressed on the relays for the effect of current passing through the main transformers and are adjusted to give to the relays a true proportion of the line to line and line to ground voltage at all times. The performance of the relaying system is being watched with particular interest, as this is one of the first installations of this type of relay on a loop that connects only generating stations.

Air Preheaters in the Power Plant

Description of Types Now in General Use and Summary of Results Which May Be Expected From Their Use

PREHEATED AIR was first used early in the 19th century, its early use and development having been confined largely to use in connection with the production of iron and steel. During the latter part of that century tests were made on boiler furnaces in which preheated air was used and its effect upon economy noted. The strange thing about this development is that so little general recognition was given to it until within comparatively recent years. The almost universal opinion of English engineers of the last century was to the effect that preheating was a fallacy and could not be anything but detrimental to combustion efficiency. That is probably the reason why this method of increasing the efficiency of steam generation did not keep up with other developments in steam engineering.

Within the last few years the use of preheaters has come into extensive use. Many of the large power plant installations being made today include air preheaters. Their value for increasing power plant efficiency has been demonstrated and they have come to take an important part in the steam power station.

At the present time there are several methods in use by means of which combustion air may be preheated. These are (1) by hollow-wall construction, (2) flat-plate heaters, (3) tubular heaters, and (4) heaters of the rotative or regenerative type. These methods take advantage of conduction and radiation of heat through the furnace walls or floor as in (1) or by the absorption of the waste heat from the flue gas as in (2), (3) and (4). Still another method is available wherein a surplus of exhaust steam may be used to preheat air.

Hollow-wall construction really serves two purposes; first that of cooling and thus protecting the furnace wall from the destructive heat of the furnace, and secondly, it serves as a means of preheating at least a part of the air used for combustion. In stoker practice it is quite common to arrange openings in the side walls through which air is admitted to a hollow section of the wall. The air passes downward and enters the furnace just above the grate line through perforated lining blocks. The lining opposite the section of hollow wall is often made of carborundum because of the fact that its rate of conductivity is about nine times as great as that of ordinary fire brick. Construction common to pulverized fuel furnaces provides for a series of dampered openings near the rear end of the side walls. Each damper controls the air which passes through a horizontal passage in the side and front walls and discharges into the furnace through openings in the front wall. This method also preheats the air and keeps three of the furnace walls cool. The rear wall is usually protected by either a water screen or a radiant heat superheater or both.

Plate type heaters consist of a steel casing in which are contained a number of steel plate elements. The gas and air are divided into alternate parallel streams which should preferably flow in opposite directions to each other; that is, assuming that the gas passes from the lower to the upper part of the heater, then the air will be drawn in at the top and taken out at the bottom. Obviously the steel plates are hottest at the point where the flue gas enters and as the gases pass along there is a decreasing amount of heat available for absorption. As a result of this counter-flow principle, the air entering at the point from which the gases leave, encounters an increasing temperature as it progresses through the heater, consequently absorbing the maximum amount of heat. The temperature difference between gas and air is thus maintained at a practically constant ratio.

Gas and Air Flow in Parallel Streams

Inasmuch as these parallel streams of gas which pass over the air elements are spaced close together, it is evident that practically all the gas is brought into immediate contact with the surface of the elements. This condition is also true of the air which is divided into parallel

streams. Because of the fact that the streams of gas and air alternate, both plates of the element are brought into contact with the hot gas. This complete contact of both gas and air with the same heating surfaces results in a most effective transfer of heat. By eliminating the natural tendency of the gas and air to stratify, the heat transfer is uniform throughout the surface of each element.

In making up a complete heater, the required number of elements are assembled side by side and enclosed in a steel plate casing suitably braced throughout and provided with flange connection on the inlet and exit gas and air openings for connection to the air ducts and flues.

It is in many cases a simple matter to keep the heater clean, because the slight weaving action of the plates will tend to prevent an accumulation of soot on the surface and will assist the gases as they pass over the elements to carry through any particles of soot which may be deposited on the plates. The air side of the elements will,

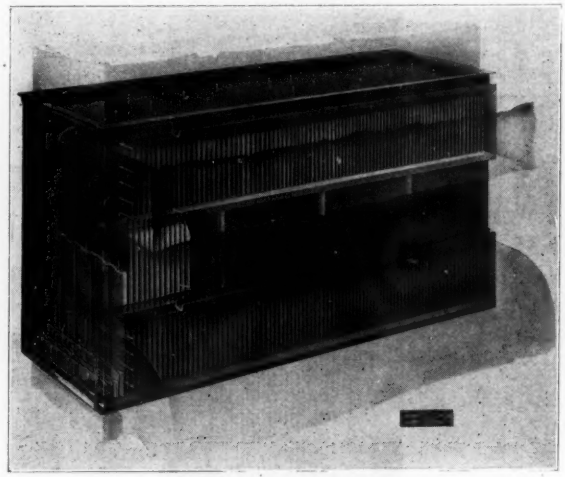


FIG. 1. PLATE TYPE PREHEATER CONSTRUCTED FOR ALTERNATE PARALLEL STREAM OF GAS AND AIR

of course, require no cleaning, as they handle only comparatively clean air. Occasionally, it may be necessary to brush the gas passages with a steel brush, or blow them out with steam or air lance.

Test results indicate that the draft loss in this type of heater is small. For this reason it is unnecessary to provide any great amount of drafts as long as the quantity of gas which it is required to handle is kept within reasonable limits. For example, the draft loss will not ordinarily exceed 0.5 in. with a gas rate of about 6000 lb. per sq. ft. of cross-sectional area per hour. Of course, the draft loss would be affected to some extent by the manner in which the heater is installed. If the gases are permitted to pass through the heater vertically, it is obvious that the draft loss would be a little less than if they travel through horizontally. Wherever the space permits, a vertical installation is usually preferred, although the problem of draft loss is not a serious one in either case.

Pressure drop through the air side may be somewhat higher than that through the gas side, due to the increased density of the air. In most installations the air is drawn through the heater by the suction of a fan which in turn is used to force it to the furnace. It is usually necessary to provide a fan for handling the air to the furnace, whether or not an air heater is used.

Thirty Per Cent of Waste Heat May Be Recovered

Saving which may be effected increases in proportion to the amount of heat available in the escaping flue gas. Thirty per cent of this heat may be economically recovered with this heater. The degree to which the temperature of the air may be raised is dependent upon the weight and temperature of the gases available, the weight and initial temperature of air to be preheated and upon the amount of heating surface.

The tubular type of air preheater consists of tubes for the passage of the flue gases with arrangements for passing the air over their external surfaces. There are ordinarily several passes for the air, so arranged as to give a counterflow between the gas and air.

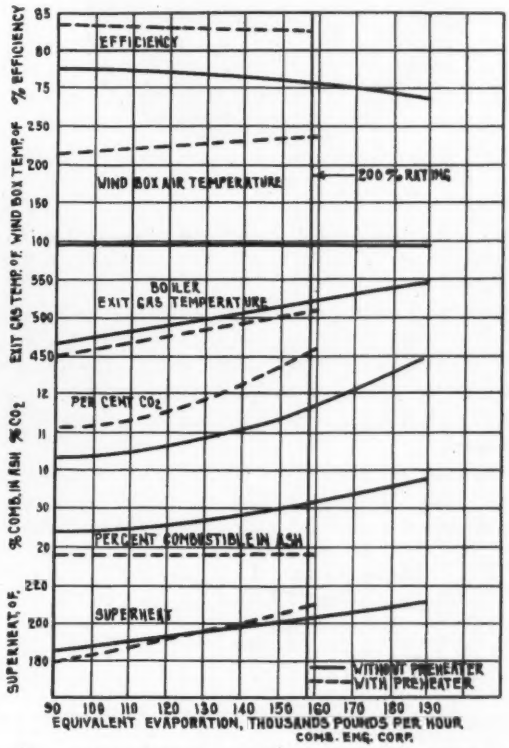


FIG. 2. COMPARATIVE RESULTS OBTAINED WITH AND WITHOUT AIR PREHEATERS

Regenerative type of reheaters consists of a cylindrical vessel made of steel plate. This vessel is horizontally divided into three compartments, the middle one containing a rotating member, called the rotor, which at its periphery is supported on three carrying rollers. The rotor, which is kept in a continual rotation of about 6 r.p.m., is divided, by means of partitions, into a number of sections, each section being filled with heating elements, which are built up from corrugated thin steel sheets, alternating with plain sheets. In this manner a great number of axial channels or passages through the rotor are formed and the required heating surface is provided.

In the other two compartments, each comprising about one-third of the preheater vessel, two diaphragms are arranged parallel to each other and to the geometrical axis of the rotor. This divides the vessel into four compartments of which the two upper ones, by means of the great number of passage through the rotor, communicate with the corresponding lower ones, or in other words, the pre-

FIG. 3. REGENERATIVE TYPE OF PREHEATER CONSISTS OF A ROTOR WITHIN A STEEL SHELL

heater vessel is axially divided in two halves, the flue gas being confined to one side of the partition and the air to the other.

Two fans mounted on a common shaft are provided by means of which the required circulation of flue gas and fresh air is secured. The power for driving these fans and also for revolving the rotor is supplied by a small electric motor, steam turbine, or some other suitable source of power.

Cleaning the elements is accomplished, without interfering with the regular working of the preheater, by means of a soot-blowing device operated with steam. This operation is completed while the rotor makes one revolution, thus requiring but a few moments.

Hot flue gas from the boiler is introduced into the lower compartment, whence it passes through the rotor while giving up the greater part of its heat content and finally is exhausted and impelled to the stack by the fan, which is located in the upper compartment of the preheater.

Fresh air traverses the apparatus in the reverse direction, being drawn into the upper compartment by means of a fan and forced downward through the rotor, whence it is conveyed to the furnace after having absorbed the heat stored in the elements.

As the rotor slowly turns around, the elements, which have been heated by the flue gas passing from the one chamber to the second chamber, are continually brought into a position to be cooled by the air sweeping through the rotor. Simultaneously, the cooled part of the elements is continually returned into a position to be treated by the flue gas. Thus a continual transportation of heat from the flue gas into the combustion air is effected in a mechanical way.

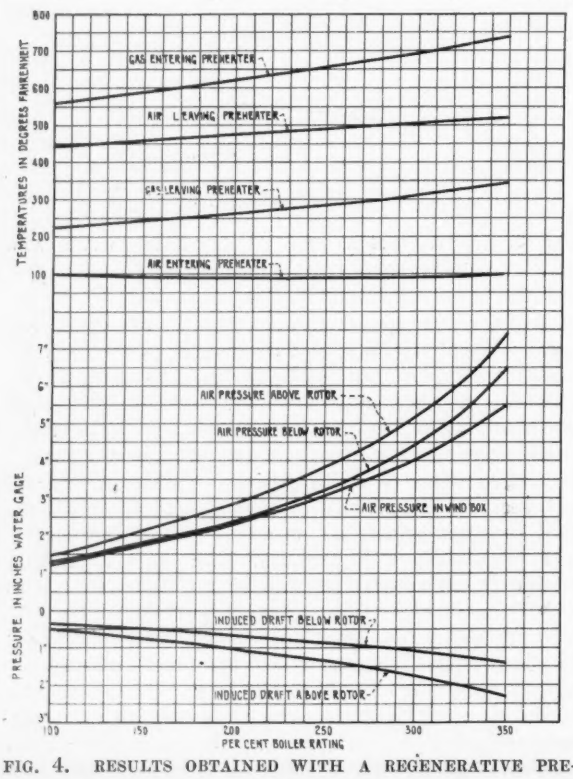


FIG. 4. RESULTS OBTAINED WITH A REGENERATIVE PREHEATER ON A 1420-HP. STIRLING BOILER

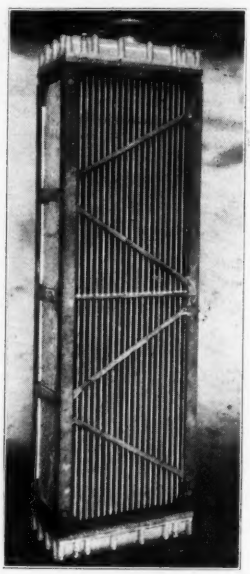


FIG. 5. ONE SECTION OF A PREHEATER IN WHICH STEAM IS USED TO HEAT THE AIR

Alloy Plates Can Be Used to Retard Corrosion

These machines are rated so that 50 per cent of the heating elements can be lost, due to corrosion, and still they will be effective as reheaters. Where the corrosion difficulties are unusually severe the heating elements and fans can be made of chromium steel, thus materially reducing the tendency towards corrosion.

Steam air preheaters may be employed to raise the temperature of the combustion air beyond that added by the gas air preheaters. Furthermore, in industrial plants, where large quantities of exhaust steam are available, or in existing central stations where exhaust or extraction steam may be obtained, the steam air preheater provides a means of effecting economies with a minimum of machinery and building modifications.

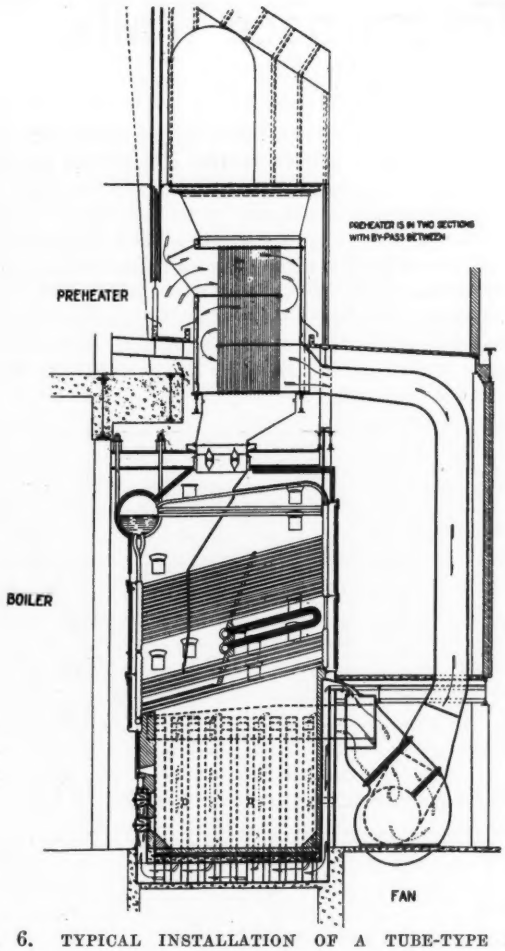


FIG. 6. TYPICAL INSTALLATION OF A TUBE-TYPE AIR PREHEATER

Gas air preheaters must be designed to handle the impure products of combustion; facilities must be provided for cleaning them and material must be used which will resist corrosion, whereas only air flows through the steam air preheater and there is no tendency for the dust or dirt in the air to adhere to the surface. This makes possible a much more compact design than is possible with the gas air preheater and permits the use of metals and an arrangement of surfaces which greatly improve the unit heat transfer. Because of the lower resistance to heat transfer in the steam air preheater and the use of brass and copper, which still further reduces the resistance, the heat transfer per square foot per degree per hour is in approximately the order or magnitude of 2 for the gas air preheater, against 10 for the steam air preheater. These figures, of course, are subject to much variation, depending on many conditions, principally the velocities of the fluids.

Transferring heat from air to water, a practice now quite generally adopted for cooling turbine-generators, presents just the same problem as transferring heat from steam to combustion air, and, therefore, the steam air preheaters are not dissimilar from surface air coolers. They are sufficiently compact to permit installations in places where the gas air preheater cannot be installed. They will not interfere with the stack draft in plants which are dependent on natural draft for combustion and they can be arranged in two or more stages so as to utilize extracted steam at whatever pressures are available.

Summing up, the following results from the use of preheated air may be expected: In all probability the temperature of preheated air will be restricted in stoker practice to 450 deg. F., at least until further knowledge is obtained on the subject. It has been found that preheated air increases the furnace temperature from 1/10 to 1/3 of the range through which the air is heated. By admitting warm air above the fuel bed, high volatile coals may be burned to a better advantage. Cheaper coals, containing high moisture, volatile and ash content, can be burned more economically.

It is probable that increased clinker trouble may result from the use of preheated air with coal containing ash having a low fusion point. It may be expected that increased boiler efficiency will result from the improved combustion and that the over-all boiler efficiency will be increased from 5 to 10 per cent, due to the heat recovery from the waste stack gas. It has been found that the flue gas temperature at the end of the last pass is lower at a given rating with preheated air.

Infiltration ahead of the preheater and some stack loss being unavoidable, result in not over 80 per cent of the stack gas heat being recovered. Air preheaters are increasingly important where high steam temperatures result in higher gas temperatures. A higher percentage of CO_2 can be carried with the same temperature of exit gases. Finally, the capacity of the installation will be increased from 5 to 15 per cent by the use of preheated air, provided that the increased furnace temperatures do not offset the gain.

Money Saved by Ball Bearings

By W. F. Schaphorst

IN AN instance brought to the attention of the writer, the installation of ball bearing hangers, and of ball bearings on line shafting, resulted in using 25 per cent less power than formerly. The entire plant has now been equipped with ball bearings. A report concerning this plant contains the following interesting information in one paragraph:

"One section supplied by a d.c. generator required between 1600 and 1800 amp. at 130 v. when babbit bearings were used. The same load is now handled with a current of 1200 to 1300 amp., which shows that the minimum reduction is about 25 per cent of the original load. The power saved per day is 468 kw-hr. which in a year's time at $0.02 per kw-hr. is worth $2808. As this section of the plant takes about 1/3 of the total amount of power used, the saving from the use of ball bearings in the entire plant would be approximately $8424 per year."

We also read and hear much criticism concerning the life of ball bearings but the manufacturers of the above ball bearings claim that their bearings have been used steadily for 10 yr. They say that ball bearings ,"Cost more than babbited bearings of course, but they pay back the difference in cost, in power saving alone, in less than 2 yr. time, and after that they are earning a clear profit.

A CALL-DOWN or criticism, justly administered in a straightforward, sincere manner, will do more good than a world of praise.

Heat Losses From Boiler Furnace Walls

Radiation and Convection Losses Determined by Air Velocity as Well as Temperature Difference.* By L. B. McMillan**

EVEN THOUGH the rate of heat loss from a surface is maintained at a given temperature, it may be greatly increased by air circulation over the surface. This is illustrated in Fig. 1, which shows the factors by which losses under still air conditions must be multiplied to find the loss at a given velocity. These curves are based on

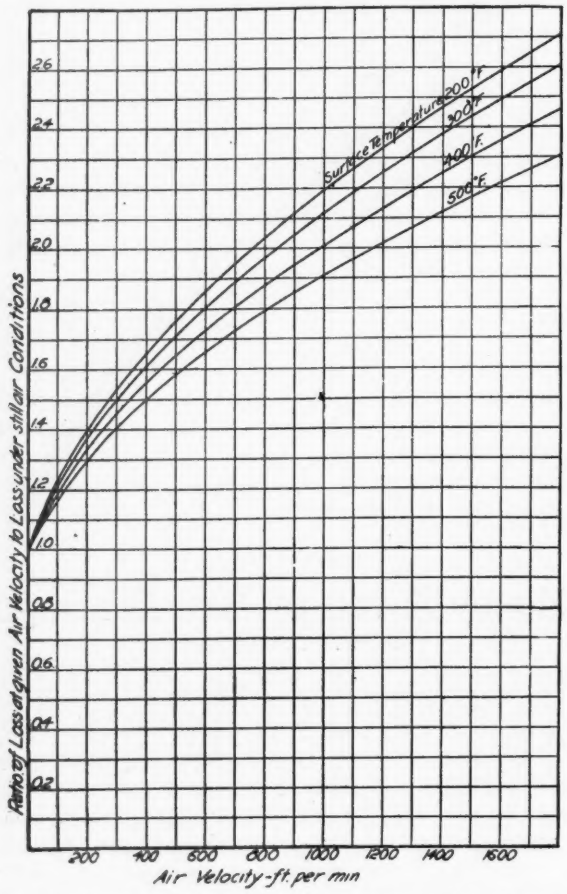


FIG. 1. RATIOS OF HEAT LOSSES WITH MOVING AIR TO STILL AIR AT SAME TEMPERATURE

Langmuir's equations for convection and increase in convection losses due to air velocity. Many other investigators have shown increases in rates of heat loss of much greater magnitude. In fact, some show increases approximately double those illustrated in Fig. 1 and it has been shown that still further increases may occur if air currents strike the surface obliquely instead of flowing parallel to it or impinging directly upon it. Therefore, the values represented by the curves in Fig. 1 may be regarded as showing conservatively the minimum effects of air velocity and in a given case the effect will probably be much greater rather than any less than these values.

The reason for the different rates of increase for surfaces at different temperatures is that heat transmission from surfaces takes place partially by convection and partially by radiation. Air circulation affects only the convection. At a temperature of 400 deg. F., the radiation component which is unaffected by air velocity is a larger proportion of the total transmission than it is at 200 deg. F., consequently a given increase in convection affects the total less at 400 deg. F. than at 200 deg. F. For temperatures less than 200 deg. F. the convection component tends to decrease more rapidly than the radiation component, so that the curve for 100 deg. F. would lie near that for 300 deg. F.

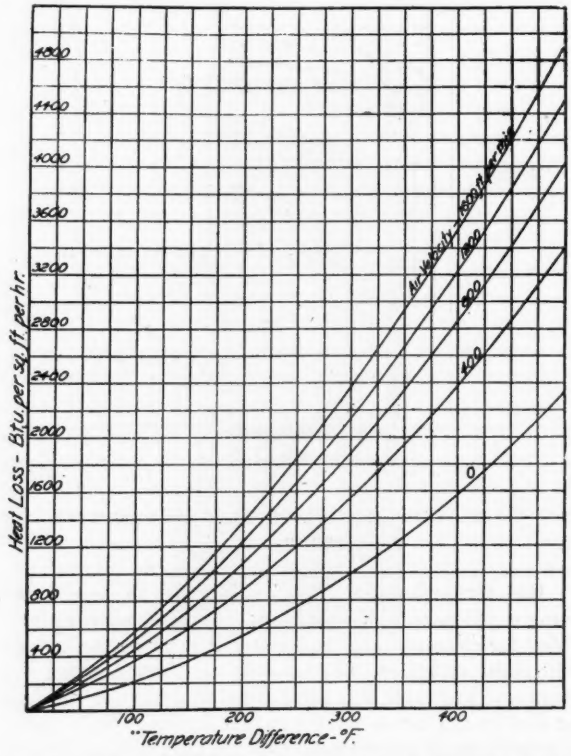


FIG. 2. HEAT LOSSES FROM SURFACES AT VARIOUS TEMPERATURES AND EXPOSED TO DIFFERENT AIR VELOCITIES

In spite of these variations in increase factors, however, the losses are materially increased by air velocity at all temperatures. This point is brought out more clearly in Fig. 2, in which total losses are shown for various temperature differences for each of the following velocities: 0, 200, 400, 800 and 1600 ft. per min. It is apparent from these curves that air velocity is almost as important a factor in determining heat loss from a surface as the temperature difference between the surface and surrounding air.

Air circulation over the surface of a brick wall increases the rate of heat transmission from the surface according to the factors shown in Fig. 1 and as previously pointed out, this tends to cool the surface and increase the heat loss through the wall. Therefore, while the increase in heat loss is not as great as for surfaces maintained at constant temperature, the outstanding fact is

* Abstract of paper presented at Fuels Saving Conference, May 13-14, 1925.
** Chief Engineer, Johns-Manville Co.

that, with a lower surface temperature, the wall is transmitting more heat. This fact may be illustrated more clearly by reference to Fig. 2, where it may be seen that the rate of heat transmission from a surface 100 deg. F. above air temperature and exposed to an air velocity of 400 ft. per min. (approximately 4.5 mi. per hr.) is greater than for a surface 150 deg. F. above air temperature but exposed to still air.

From the preceding facts it is evident that misleading conclusions are likely to be reached if surface temperature alone is taken as an index of heat losses. Air circulation not only increases the rate of heat transmission from the surface, but since the velocity is rarely constant over a long period of time, it also introduces variations in surface temperatures and in temperatures of air adjacent to the surface. A familiar example illustrating these points is the case of a boiler plant where the tem-

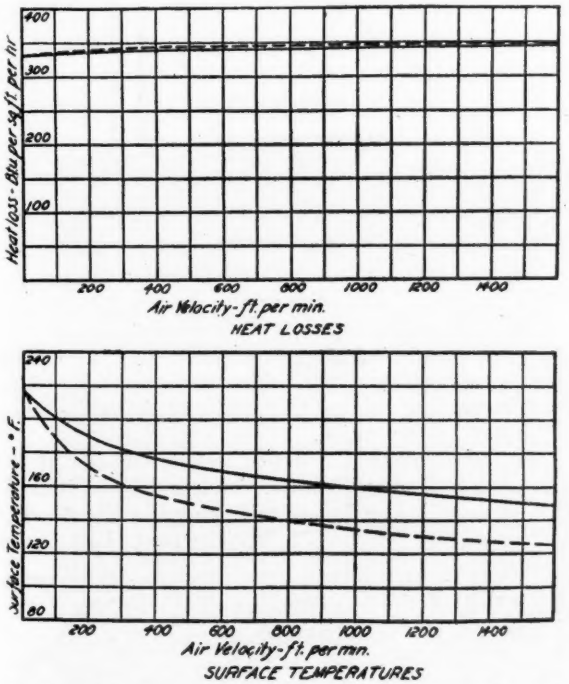


FIG. 3. EFFECT OF AIR VELOCITY ON HEAT LOSSES AND SURFACE TEMPERATURE OF INSULATED WALL

perature of the wall of the end boiler is usually lower than that of the walls adjacent to the alley between batteries yet, other conditions being the same, the loss from the more exposed wall is undoubtedly the greater.

In the case of insulated walls, the variation in rates of heat transmission due to air circulation is less than for walls without insulation; because, as pointed out above, the higher the total resistance to heat flow the less the results will be affected by variations in surface resistance. However, while these variations in surface resistance have little effect on the total heat flow, they do have a marked effect on surface temperatures. This is illustrated in Fig. 3, which is based on a 13½-in. thickness of fire brick at 2000 deg. F. inside face temperature, with a conductivity of 7.5 B.t.u. per sq. ft. per deg. temperature difference per 1 in. thick per hr., insulated with 2½-in. thick insulation with a conductivity of 0.7 B.t.u. per sq. ft. per deg. temperature difference per hr. Surrounding air temperature 80 deg. F.

$$R_b = \text{Resistance of Brick} = \frac{13.5}{7.5} = 1.80$$

$$R_1 = \text{Resistance of Insulation} = \frac{2.5}{0.7} = 3.58$$

$$R_s = \text{Surface Resistance (from Fig. 4)} = 0.42$$

Total Resistance, 5.80

$$\text{Heat loss} = \frac{2000 - 80}{5.80} = 331 \text{ B.t.u. per sq. ft. per hr.}$$

The above individual resistances expressed as percentages of the total resistance are interesting in that they show the relative effects contributed by each element of the construction:

Resistance of brick wall in the foregoing example = 1.8; $\frac{1.8}{5.80}$ = 31.1 per cent of total.

Resistance of insulation = 3.58; $\frac{3.58}{5.80}$ = 61.7 per cent of total.

Surface resistance = .42; $\frac{.42}{5.80}$ = 7.2 per cent of total.

It is apparent, therefore, that the insulation offers much the greater part of the total resistance to heat flow, and that the loss from the insulated wall is small as compared with that from uninsulated wall. Computations similar to the preceding for the wall without insulation, other conditions being the same, show a heat loss of 909 B.t.u. per sq. ft. per hr. Therefore, the saving by insulation is 578 B.t.u. per sq. ft. per hr. At a cost of heat of only 20 cents per 1,000,000 B.t.u., this saving is equivalent to $1.10 per sq. ft. per yr. If the walls were exposed to air circulation, the saving would be even greater, because the increase in loss from the uninsulated wall would be much greater than for the insulated wall.

Surface Temperature Not Reliable Indication of Heat Flow

Reference to Fig. 3 illustrates clearly the fact that surface temperatures do not give a reliable measure of conduction losses. In the first place, the effect of air circulation is to increase the heat losses and to decrease the surface temperature. Therefore, under these circumstances, the lower surface temperatures are by no means indications of a lower heat loss. It was pointed out that the increases in heat transfer from surface due to air circulation might in some cases be much greater than those shown in Fig. 1. The solid curves in Fig. 3 are based on the factors given in Fig. 1, while the dotted curves represent what would occur if the increases in surface losses were double those given in Fig. 1. It is apparent that the heat losses through the insulated wall would be changed only slightly, but the surface temperature would be still further decreased. In addition to variations due to air circulation, there are other effects, such as nature of the surface and exposure to other hot or cold surfaces which introduce additional variables affecting the relationship between surface temperatures and heat losses. While these variables have relatively little effect on the total heat transmitted through an insulated wall,

vice may be followed from Fig. 2; (1) shows the device, they may have entirely disproportionate effects on surface temperatures.

The temperature drop through each element in the construction is given approximately by the multiplying of the percentages in the example by the total temperature drop from inside surface to surrounding air, 1920 deg. F. in the foregoing example. However, the temperatures actually obtained at various points in the construction are usually lower than values calculated in this manner because of conduction of heat along the wall itself from the high temperature zone to cooler parts of the wall. Where there is a relatively large amount of air infiltration, the temperatures will be much lower than the calculated values; however, insulation may be applied in a manner to reduce effectively the losses due to this infiltration, as well as the losses due to conduction through the wall. Boiler wall coatings are sometimes used, even on furnaces other than boiler furnaces, to prevent infiltra-

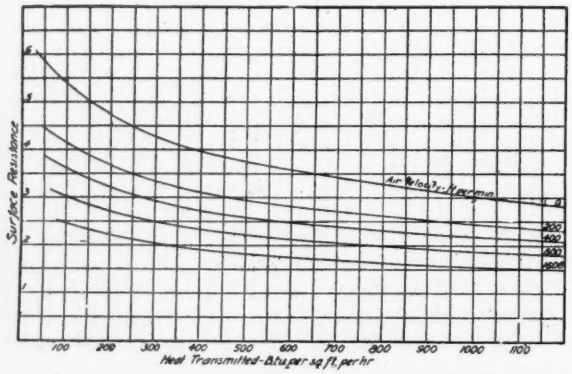


FIG. 4. SURFACE RESISTANCE AS AFFECTED BY AIR VELOCITY

tion, but these are not insulations and offer practically no resistance to conducted heat. On the other hand, insulation may be made to serve a double purpose, with the result that the combined savings from reducing conduction losses and infiltration losses greatly exceed the savings due to its insulating value alone.

Within the limitations of refractories as to temperature, the effect of insulation of the furnace walls, suitably proportioned and properly applied, may be regarded as beneficial rather than otherwise; because the use of insulation results in more uniform temperatures in the wall, and it is unequal expansion rather than expansion alone that is most injurious to walls. The maintaining of more uniform temperatures tends to prevent cracking of the wall, and to minimize the inequality of stresses which result in the spawling of the bricks. An example of this is the effect of insulation in decreasing damage to brick due to shock stresses during heating and cooling of walls.

BROOKLYN EDISON CO. is planning to install an 80,000-kw. turbo generator in its Hudson Ave. station in addition to the three 50,000-kw. units already in use. When the station is completed, it will have eight units and a capacity over 700,000 kw.

NEVER TAKE UP too tight on the packing glands of a centrifugal pump. The result of such practice is the burning up of the packing and the scoring of the runner shaft.

Starting Centrifugal Pumps Without Priming

BY C. H. S. TUPHOLME

ALL POWER plant engineers who have had any experience with centrifugal pumps are aware of the difficulties often met with in starting up the pumps, especially if the pumps are located much above the level of the water they lift. As a general rule, they will have found

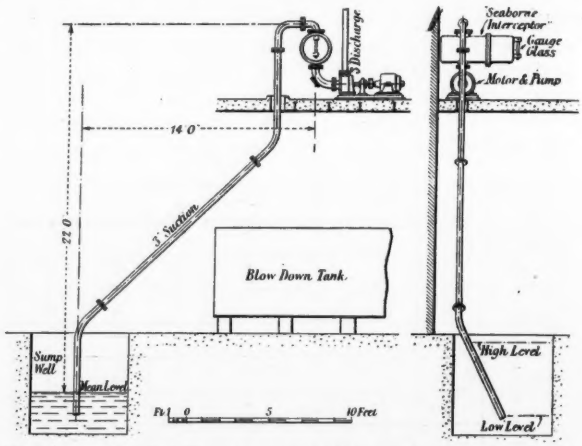


FIG. 1. FOOT VALVE WAS NOT MADE USE OF IN THIS INSTALLATION

that water has leaked away through the foot valve, leaving the casing full of air, which must be displaced by priming water or removed by an injector before the pump can be put into operation.

In this connection, a device installed at one of the big London plants will prove of interest. The installation, made without a foot valve, is shown in Fig. 1. The vertical suction lift was 22 ft. The pump here has to

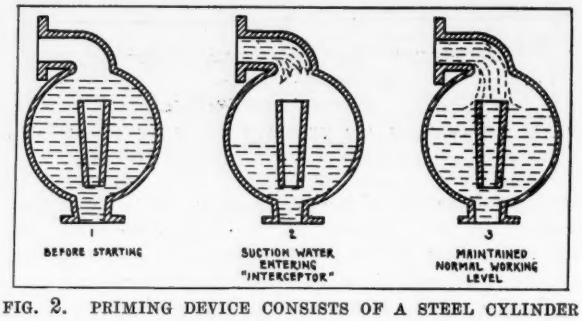


FIG. 2. PRIMING DEVICE CONSISTS OF A STEEL CYLINDER INSIDE OF WHICH IS A CONICAL PIPE

empty a dirty-water sump at frequent intervals, discharging into an overhead tank. The device installed, shown in Fig. 1, enables the pump to be started at once without preliminary priming or any other attention, regardless of the suction lift within reasonable limits. The use of this device enables the pump to be started as easily as if it had been submerged.

The device consists of a closed steel plate cylinder located on the suction line of the pump and on a somewhat higher level. The inlet to the device is at the top and the outlet to the pump immediately beneath, a conical pipe being fixed between the two. The action of the de-

having been primarily filled, ready for operation; (2) shows that, when the pump is started, it draws water from the device, creating a partial vacuum in the upper part, causing suction water to rise up the suction pipe and flow into the top. This ordinarily begins when the device has been about half emptied by the pump; (3) shows that, within a few seconds after starting, the incoming water catches and entrains the rarefied air in the device, conveying it through the pump. The device then continues operating practically fully charged with water. The water entraining the rarefied air does, in fact, become aerated, and air bubbles are seen in the discharge water for a short time after the pump has started.

To secure satisfactory operation under all conditions of operation, including the uncovering of the suction pipe, the cubic capacity of the discharge pipe from the pump is greater than that of the device. When the pump is stopped the water in the discharge pipe flows back through the pump, up through the device and away through the suction pipe. This back flush is advantageous in completely filling the device and also in washing out any refuse which may have been brought in while operating. If the pump has worked down so low as to empty the device, there will be sufficient air in the discharge pipe to flow back and refill the device after the pump has been stopped.

Cost Analysis Indicates Way to Economy

CAREFUL ANALYSIS OF POWER COSTS IN CINCINNATI OFFICE BUILDING SHOWS THE ADVISABILITY OF RETAINING THEIR PRIVATE PLANT.

ABOUT 85 per cent of the troubles encountered in old power plants can be solved by the application of common sense plus the normal ability to select modern devices necessary to secure improved economy. In most cases the direct cause of the high cost of operating old plants lies in the obsolete inefficient equipment installed, and the substitution of modern apparatus will materially increase the revenue derived from the operation of the plant.

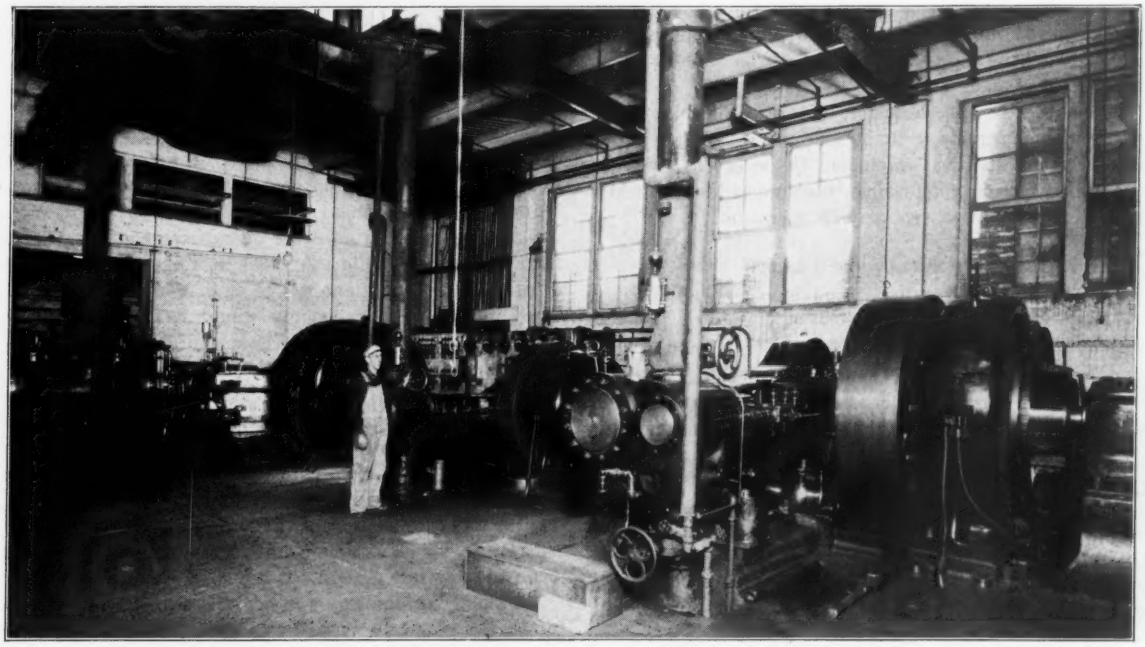


FIG. 1. VIEW IN ENGINE ROOM SHOWING TWO OLD HARRISBURG UNITS IN THE CENTER FOREGROUND AND THE NEW SKINNER UNAFLOW ENGINE AT THE LEFT

In the case of an old isolated plant, which has not been maintained in the best of condition, there comes a time when the Central Station Power Co. can easily show the losses and convince the owner that the plant should be abandoned. Before scrapping a plant of this type and arranging for the purchase of electrical energy it will usually pay to make some careful studies in regard to power costs.

Where the coal consumption for heating purposes is a large item and where there is a large proportionate and continuous demand for current there is justification in isolated plant operation. On the other hand, there are cases where either one or the other item of heat and lighting is of minor importance and where central station power is the logical step. This can easily be determined from analysis.

An interesting condition of the type referred to above arose several years ago in connection with the power plant serving the "Edwards" Bldg. in the downtown district of Cincinnati. The problem here was probably different, although the facts involved in the solution were relatively the same. This plant in addition to serving the Edward's Building and a loft building devoted to light manufacturing, also supplied heat, light, power and other utilities to about 25 outside customers within the block. It was therefore a "block" plant and was operating as a Public Utility Corporation and had filed at Columbus, a schedule

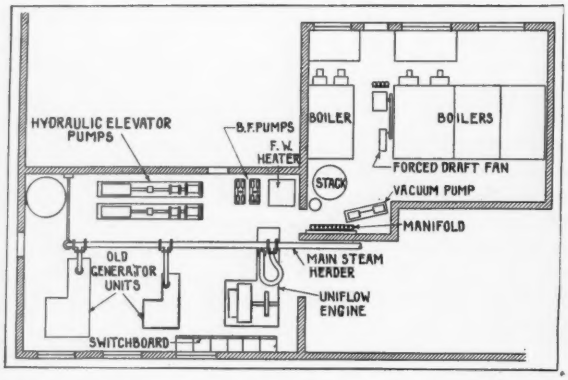


FIG. 2. DIAGRAM SHOWING ARRANGEMENT OF EQUIPMENT IN THE PLANT

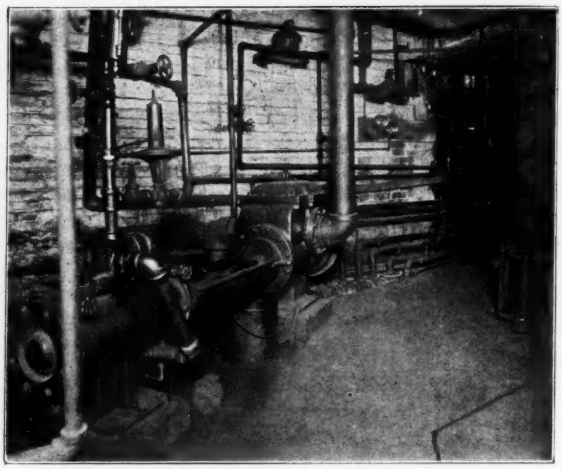


FIG. 3. THE VACUUM PUMP FOR THE HEATING SYSTEM

of rates on current which governed the revenues of this particular service.

The plant had been in operation for a period of 20 yr., during which time no depreciation fund had been set up to replace the equipment nor had any effort been made to maintain efficient operating conditions. When the present owners acquired the property, the power plant had reached a stage of deterioration where it had to be abandoned or radical changes made to restore its value.

To complicate the situation further, the plant was tied up with contracts with outside customers for light, heat and other utilities which had to be carried out. It was, for this reason, not feasible to abandon the plant and the problem was one of economy in operation.

Description of Plant

Main equipment in the old plant consisted of four boilers equipped with Jones underfeed stokers, together with engines, generators and auxiliary equipment. The boilers were of the following makes and capacities: one 200 hp. Tudor return tubular boiler and three Erie City water-tube boilers rated at 250, 300 and 350 hp. respectively, making a total of 1100 b.hp.

In the engine room there were three engine driven generator units, one, a 250-kw. unit driven by a 4-valve Watertown engine, one 200-kw. unit and another 100-kw. unit, both driven by Harrisburg counterflow engines. The generators were all 250-v. direct current units made by the Triumph Electric Co.

Two steam driven hydraulic elevator pumps, house pumps, vacuum pumps, together with the usual auxiliary equipment, completed the plant.

Of the three engines the two Harrisburg units were in good operating condition, although they consumed the excessive amounts of steam usually required by the slide valve type of engines. The three generators were also in excellent condition. The Watertown engine, however, was in extremely poor shape and was a worthless handicap. In fact it was entirely dangerous from an operating viewpoint. As a result, the 250 kw. generator was idle and had not been in service for 3 or 4 yr. This was unfortunate, since this generator had ample capacity to carry the entire load. This machine, in fact, formed the basis of the changes subsequently made which placed the operation of the plant on an economical basis.

Practically every steam joint in the plant was leaking and much of the steam piping and other heat radiating surfaces were uninsulated. Steam lines were insufficiently drained and many of them contained water pockets. There was also an excessive amount of pipe work which had accumulated throughout the life of the plant and much of it was rendering no service.

In the preliminary considerations which finally led to the rehabilitation of this plant, the first step was to make a complete analysis of the cost of operation under the then existing conditions. In this study the following factors were taken into account: coal, labor, maintenance, space, rental and management. The result gave a cost figure which showed that they were operating at a figure higher than the low schedule rate filed at Columbus, and it indicated that if the plant was to be operated on a profitable basis, the increased economy would have to be obtained through the use of new improved equipment.

Under the old operation the company was purchasing about two-thirds of the total current used from the local public service company and producing the remaining third.

The next step was a study based on the cost of operation using all purchased current, which meant the abandonment of the generating units. This purchased power also had to carry its portion of the burden of fixed charges and operating expenses. The result still showed a figure higher than the low rate schedule to which they were confined.

Finally, an analysis was made, based on the generation of all the power through the installation of a modern uniflow engine, direct connected to the 250-kw. generator which, as was stated, was in excellent condition. This study gave a much lower cost for power than either of the two previous studies, so that this was the plan decided upon.

Description of Changes Made

The basic change was, of course, the junking of the old Watertown engine. A new 400-hp. Skinner Universal Unaflow Engine was ordered and this was direct connected to the 250-kw. generator. As was stated previously, it was the installation of this highly efficient engine which was largely responsible for the economies effected in the subsequent operation of the plant. This unit is fully capable of handling the entire load so the remaining two engines are used only as standby units.

Next, all of the excess piping was pulled out, and the remaining lines straightened and rearranged with suitable

drip pockets and traps which eliminated the dangers previously existing. All heat conveying and exposed radiating surfaces were then thoroughly insulated with the best 85 per cent magnesia insulation.

The boilers were old, but as it was not feasible to make all the proposed changes at once it was decided to keep them in service for a few years longer. The boiler settings were thoroughly restored, brickwork was repaired and insulation was improved. Tubes and other heating surfaces were cleaned, and all auxiliary mechanism overhauled so that maximum results could be obtained in steam production.

Another part of the plant in which considerable improvement was effected was in the heating system for the block service. Here the heating lines were rearranged and a zone system installed so that the distribution of the exhaust steam for any section or building in the block can be controlled by the engineer through suitable valves. The manifold controlling the heating service may be seen in Fig. 3.

The value of the distributing mains was also increased materially. One vacuum pump in the engine room now handles the entire block load system. By means of these changes it has been possible to supply satisfactory heating service to the outside customers as well as to the Edwards Bldg. property on 1 lb. pressure and about 8 in. of vacuum.

With regard to the fuel used, a high grade bituminous nut and slack coal has been found satisfactory. Excellent results have also been secured with screenings from Pocahontas lump coal which accumulates in the dealer's yard. When this latter coal is available at a relatively low price, it has proven to be the most economical.

The matter of fuel supply is rather an awkward one, due to the fact that practically no storage space is available and they have to depend upon daily truck deliveries to the boiler pits. It is necessary to use a high grade of coal at this plant because the smoke ordinances in this central location are rigidly enforced.

An automatic damper control apparatus regulates the draft and CO_2 recorders which will soon be installed will aid still further in improving combustion efficiency.

The figures leading to the decision to rehabilitate this plant will no doubt be of interest to other engineers confronted by similar problems. The following summary shows quite clearly what modern equipment will do for the isolated plant in the way of economy.

FIG. 4. THE BOILER ROOM

POWER AND LIGHT ANALYSIS 1921-22

Total power and light purchased and produced. Electric power purchased 600,100 kw-hr. Electric power produced 230,610 kw-hr. Total 830,710 kw-hr. Total revenue from power and light $41,953.99. Average sales price per kw-hr. 5.05 cents.

TOTAL COAL PURCHASED—ALL OPERATIONS

Coal, tons	2708
Coal, cost	$15,871.95
Average price per ton	5.85

COAL DISTRIBUTION FOR PLANT IN TONS

Power and light, tons	829
Heating, tons	760
Hydraulic elevators, tons	535
Hydraulic pumps and auxiliaries, tons	201
Live steam, tons	383

CHARGES AGAINST POWER AND LIGHT OPERATION

Coal	$ 9,295.45
Fixed charges	5,040.00
Space rental	1,750.00
Maintenance	1,300.00
Labor	7,902.80
Management	200.00
	$25,288.45

OLD OPERATION

Purchased power	$12,311.00
Coal	9,295.65
Labor	7,902.80
Space rental	1,750.00
Fixed charges	5,040.00
Maintenance	1,300.00
Management	200.00
Total	$37,799.45
Cost per kw-hr.	4.55 cents

OPERATION BASED ON ALL PURCHASED CURRENT

830,710 kw-hr.	$17,037.86
Coal (heating plant)	3,800.00
Labor	6,750.00
Space rental	1,750.00
Fixed charges	5,040.00
Maintenance	650.00
Management	200.00
Total	$35,227.86
Cost per kw-hr.	4.24 cents

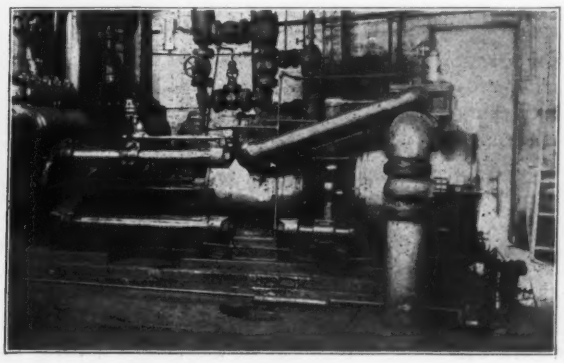


FIG. 5. ONE OF THE STEAM DRIVEN HYDRAULIC ELEVATOR PUMPS

In considering the overhead factors in the operation based on all purchased current, allowance was made in the provision for labor and maintenance. Under the present working conditions it is necessary to produce steam for the operation of the hydraulic elevators and for live steam process users in the loft buildings during the entire year. It is necessary to maintain the engineering staff under a slightly reduced basis.

OPERATION BASED ON ALL GENERATED CURRENT WITH MODERN UNIFLOW ENGINE

830,710 kw-hr. at guaranteed 5 lb. per kw-hr.	2,076.77 T.
Coal	$10,383.88
Labor	7,902.80
Space rental	1,750.00
Fixed charges	7,140.00
Maintenance	1,200.00
Management	200.00
Total	$28,576.68
Cost per kw-hr.	3.44 cents

It will be seen that these latter figures are practically the same as for the old operation with the exception of the fixed charges which have been raised to include the additional investment in the new engine.

In addition to the actual improvements effected in the power plant another phase of the rehabilitation work was a careful revision of the rates for heating. It was found that the previous owners had been selling heat at rates which not only did not permit an adequate return but which were unequitable insofar as the customers were concerned. The entire schedule of heating rates was therefore gone over and placed upon a profitable as well as equitable basis. At the present time the revenue from the sale of exhaust steam for heating purposes offsets the coal bill for all other operations and it gives the owners a considerable net return on the power and heat operations.

To cite an example of the return which is obtained, we have taken from the records the figures for the month of November, 1923, and are presenting them herewith. This is typical of the average run during the 7 mo. heating season. During this month 75,450 kw-hr. were produced which were sold at an average price of 5.3 cents per kw-hr.

INCOME

75,450 kw-hr. at .053	$4,198.85
Revenue from heat	1,607.26
Total revenue	$5,806.11

EXPENSES OF OPERATION

Coal	$1,569.75
Labor	1,320.00
Fixed charges	600.00
Maintenance	272.00
Total expenses	$3,761.75
Net return	$2,944.36

The plant is now operating on a satisfactory basis and further improvements will be made as the need demands. One of the next changes will be the substitution of new modern water-tube boilers for the old ones now being operated. The first of the new units has already been ordered and will be installed within the next few weeks.

While it is possible to operate continuously and independently of the Central Power Company, the plant has been purchasing current during the summer months on a satisfactory schedule. The fact that operation could be continued on an economical basis the year round has given the owners a distinct advantage in the matter of central station power rates.

In concluding this article we wish to express our indebtedness to O. F. Slimp, manager of the Edwards Bldg., and to George Limbach, chief engineer, for assistance rendered in the preparation of this article. We also extend credit to the Proceedings of the 17th annual Convention of the National Association of Building Owners and Managers, from which certain figures contained in this article were taken and to the L. I. Snodgrass Co., of Cincinnati, O., for information regarding the Skinner engine.

Use of Small Stokers Increases

STRAWS SHOW which way the wind blows and some figures recently given out by the U. S. Department of Commerce give an indication of the trend in mechanical stoker use.

During 1924, an average of 14 firms reported sales of 1128 stokers, for a total of 514,379 hp. or average of 455 hp. per stoker. For the first 6 mo. of 1925, 13 firms reported sales of 840 stokers, 351,298 hp., averaging 420 hp. per stoker. For 1924, 161 stokers were for fire-tube boilers, averaging 150 hp. and 967 for water-tube boilers, averaging 505 hp. For 6 mo. of 1925, 151 stokers were for fire-tube, averaging 183 hp. and 689 for water-tube, averaging 470 hp.

These figures indicate increased sales, and that use of stokers for smaller plants is growing; also that in fire-tube boilers larger sizes are being installed and that water-tube boilers are being used in smaller sizes.

It is certain that the size of the largest water-tube boilers is being increased and that they are stoker equipped, so the lowering of average size of stokers for water-tube boilers can only mean a big development in use of stokers for smaller boilers.

Data are not extensive enough to make these generalizations conclusive, but the trend is supported by comparison of figures over the two years past. They are as follows:

	Fire Tube		Water Tube	
	No. Sold	Av. Hp.	No. Sold	Av. Hp.
1923—July to Dec..	96	160	478	525
1924—Jan. to Dec..	161	150	967	505
1925—Jan. to July..	151	183	689	470

IN THE HEART of Sussex, England, land of slow-moving countrymen and wood untouched since the days of the Romans, there is a 600-acre farm that is said to be the most highly developed electrically of any on earth. All cultivating and reaping is done by electricity, hay is cured without sunshine by forcing drafts of air through the mows with electric fans, milking machines and churns are motor-driven, brooders for baby chicks are heated by electricity and the hens are caused to produce 20 per cent more eggs than normal during the winter months by having lights in the laying pens at night. Even the working hours of the bees are prolonged in the spring by putting them in electric-lighted and heated houses.

—N. E. L. A. Bulletin.

Types of Foreign Marine Diesel Engines

Swedish Engines Used on M. S. Zoroaster for Prime Mover and Auxiliary Equipment. By H. F. Birnie

ONE OF THE first concerns to take up the patents of Dr. Rudolf Diesel was the Nobel Co., formerly located in Petrograd, Russia, but now located in Nynashamn, Sweden. Their latest model, called the Nobel, is installed in the M. S. Zoroaster, which visited New York in 1924. This engine presents many distinctive features and has aroused considerable interest in oil engines.

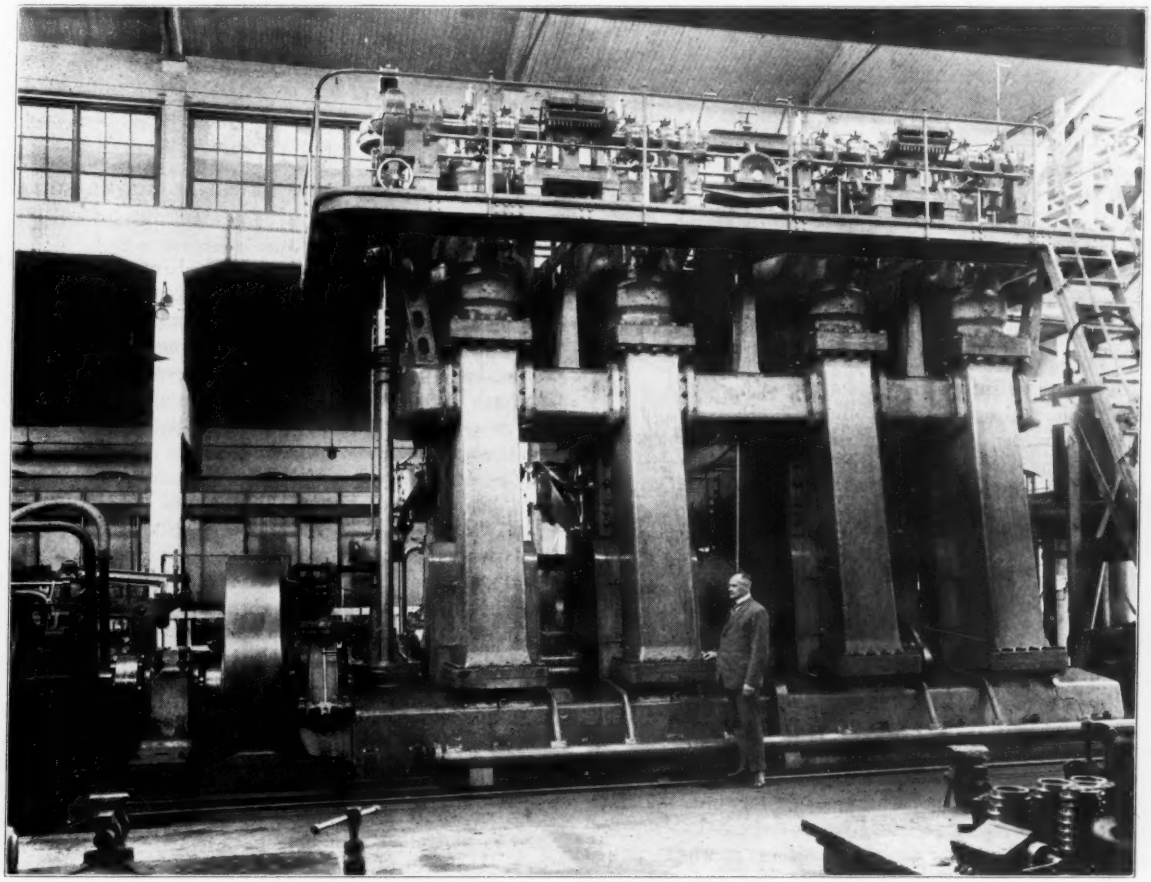


FIG. 1. SIDE ELEVATION OF 1600 HP. NOBEL ENGINE TAKEN IN ERECTING SHOP

Photographs shown in this article were taken in the erecting shop in Sweden prior to the installation of the machinery on board ship.

Figure 1 gives a general idea of the Nobel-Diesel. It is a 4-cylinder, 2-cycle, single-acting engine, having a bore of 26½ in., a stroke of 36¼ in. and develops 1600 b.hp. at 105 r.p.m. The columns supporting the cylinders are braced together by hollow cast-iron beams and act as receivers for the air used in scavenging. Air compressor and scavenging pumps are located in the back of the engine and are driven from the crossheads by means of levers. The bed plate is in two sections bolted together and the cam shaft is driven by a vertical shaft using spiral gears. To the middle, between the two center cylinders, a helical gear drives the rotary valve controlling the inlet and outlet of the scavenging pumps. This valve rotates at 1/3 of the crankshaft speed. The engine is operated from the platform. By locating all the auxiliaries in the back, the overall length is reduced.

Some of the construction details are more clearly illustrated in Figs. 2 and 3. Each cast-steel cylinder head is provided with three valves—a starting, a fuel and a pressure relief valve. The latter is connected to the scavenging air receiving space. The piston skirt is attached to the piston rod but the wiper ring is fixed in the lower end of the cylinder liner and presses inward. Sea water is used in the cooling system. There is no outward connection between the frame and the cylinder head, as the cooling water passes from one to the other of three drillings provided at the upper flange of the liner. The shape of the combustion chamber was carefully designed to insure the best possible scavenging. Intake and exhaust ports are not placed at the same level but the former reach higher in the cylinder than the latter, thus controlling the scavenging air. At first this was done by a piston valve actuated from the cam shaft, but later replaced by an automatic shutter.

In Fig. 3 is shown the peculiar design of the levers driving the auxiliary units. The fulcrum pin, instead

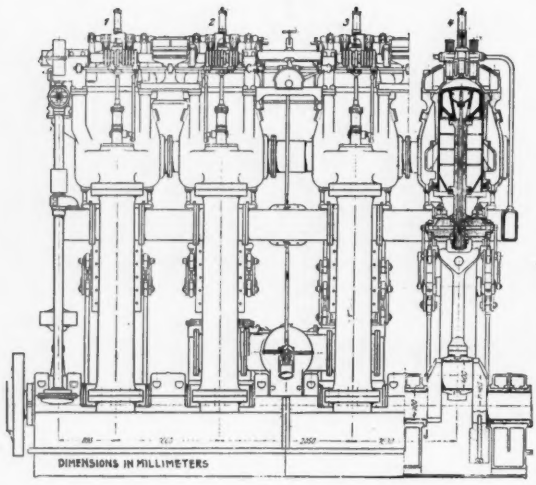


FIG. 2

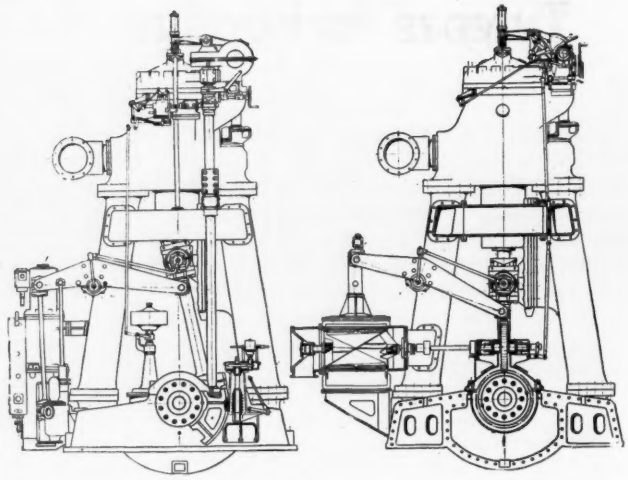


FIG. 3

FIGS. 2 AND 3. CYLINDER HEADS ARE PROVIDED WITH STARTING, FUEL, AND PRESSURE RELIEF VALVES. INTAKE AND EXHAUST PORTS AT DIFFERENT LEVELS

of being fixed in the middle, sets on the lower face of the rocker arm.

MANEUVERING CONTROLLED FROM UPPER PLATFORM

A close-up view of the maneuvering platform is shown in Fig. 4. The injection and starting air control wheels are not shown, but all the other elements are plainly visible. For each cylinder, there are two fuel cams, two starting cams, two compression relief cams, one scavenging valve control cam and one indicator motion driving cam. The handwheel at the left is used for priming the fuel cam. In the center there are three maneuvering levers and one fuel regulating device. A and B control the rocker arms by bringing them in contact with the different cams or by keeping them off their surface; D shifts the whole cam shaft back and forth, setting the one or the other cam in front of the different rocker arm rollers; C adjusts the amount of fuel going to the cylinders. An interlocking device prevents D from moving until all the rollers clear the cams. A and B can be set in three different positions. When central, all the rollers clear the cams (neutral position); when pushed forward, the starting and the pressure relief valve are acting, but the fuel valve is kept closed (starting position); when pulled backward, the fuel valve is working, but the two other valves are idle (running position).

To start the engine, A and B are first set in neutral position and D in either forward or reverse position. From neutral, A and B are then both pushed into starting position. As soon as the flywheel has made a revolution, A is pulled into running position (A controls the two cylinders at the left), and B is then brought into the same position as A, immediately after the two cylinders at the left have begun firing. When reversing, A and B are put in neutral; D is then set in the opposite position and the operation is repeated.

These maneuvering motions are generally done on the larger marine engines, with the help of an auxiliary, so-called "servomotor." The Nobel engine dispenses with the latter but notwithstanding, the engine may be brought from full speed ahead to full speed astern in 8 to 12 seconds.

It should be noted that, when reversing the engine, two other units must be considered. As the levers A and B are put in "neutral," the fuel pump is prevented from delivering by keeping the suction valves open and the scavenging air piston valve is brought in the reverse position by the shifting of lever D. This shifting lifts or drops the piston valve by means of levers acting on an eccentric shaft, so that in one case the scavenging air inlet is controlled with the upper piston ring edge, in the other case with the lower ring edge.

Another element must also be taken care of by lever D, while reversing, which is that the rotary valve of the

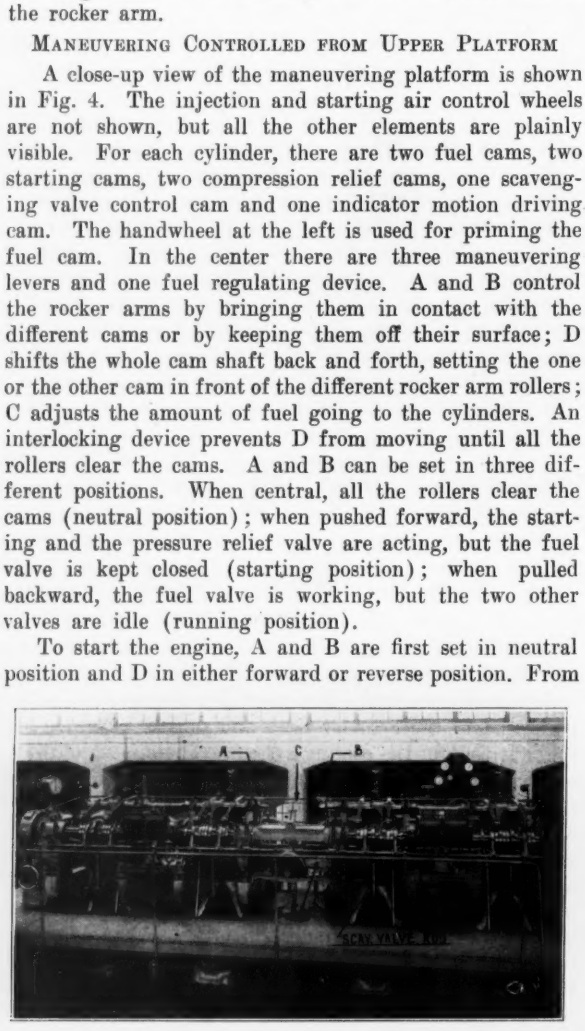


FIG. 4. MANEUVERING IS CONTROLLED FROM THIS PLATFORM

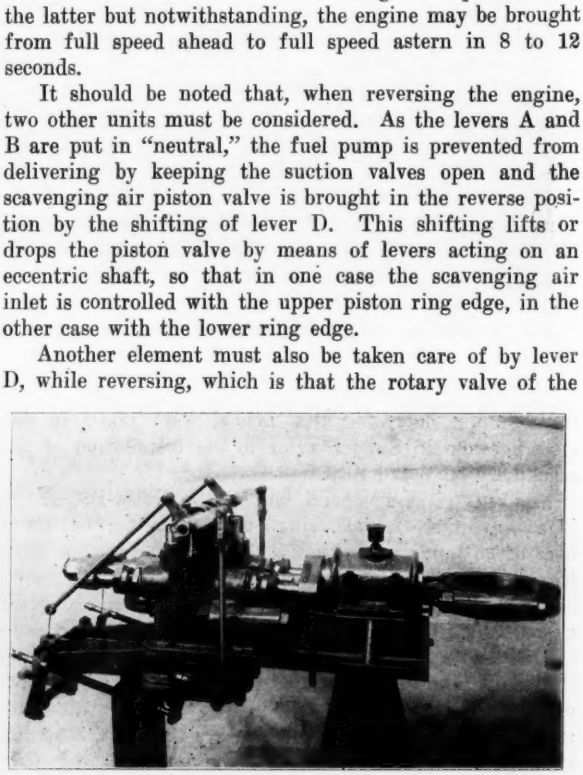


FIG. 5. SHOWS DETAILS OF THE FUEL PUMP. ECCENTRIC STRAP AT RIGHT CLAMPS VERTICAL SHAFT

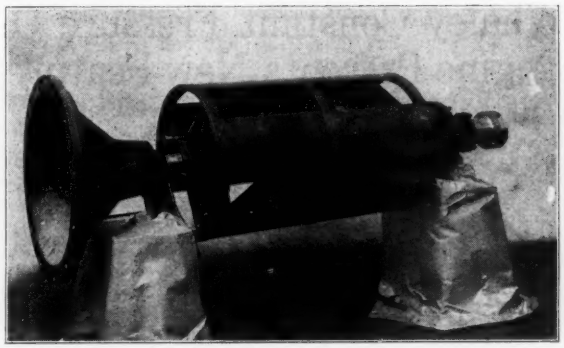


FIG. 6. CLOSE-UP OF ROTARY SCAVENGING VALVE

scavenging pump must be turned through a certain angle corresponding to the new direction of rotation. This is accomplished by three levers and an auxiliary coupling, as shown in Fig. 3.

As a rule, marine Diesels have a much better controlling mechanism than the stationary engine. The interlocking device prevents moving D unless A and B are in the neutral position, as well as making it impossible to move A and B, unless D is in either the "ahead" or "astern" position. The Nobel-Diesel also provides an auxiliary valve which prevents the flow of air to the starting valve in any position of A and B, except the starting position. This arrangement makes it thus possible to keep the starting air bottle open during maneuvering.

In Fig. 5 is shown a close-up view of the fuel pump, driven by the vertical shaft, shown to the left in Fig. 1. Figure 6 shows the rotary scavenging valve and Fig. 7 gives a view of the partly erected engine, with some of the crank-shaft counter weights in place.

Results of Tests Show Good Efficiencies

Cooling of the engine is done by sea water, which the Nobel engineers preferred instead of oil. Lubrication is of the sight-feed, gravity system (see Fig. 4), except for the cylinders and the compressor. As a means of starting, the engine is fitted with a reversible air motor which can be meshed with a gear fixed at the flywheel end of the crank-shaft. This motor may be seen in Fig. 1, bolted on a bracket, near the vertical shaft. Behind this vertical shaft is a governor, which connects to the fuel pump through a long rod and prevents any racing of the engine.

Tests made in the shops showed good efficiencies. The fuel consumption at full load and with the engine driving the scavenging pumps, compressor, water cooling pump and the lubricating oil, circulating pump was 0.394 lb. per b.hp.-hr. with a fuel of 17,900 B.t.u. per lb. The

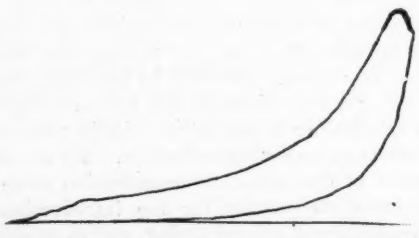


FIG. 8. INDICATOR CARD SHOWS AVERAGE COMPRESSION OF 412 LB. PER SQ. IN.

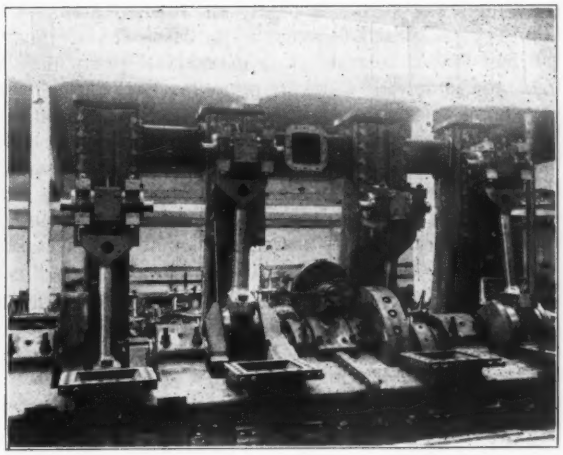


FIG. 7. PARTIALLY ERECTED ENGINE WITH COUNTER WEIGHTS OF CRANK-SHAFT IN POSITION

brake mean effective pressure at that load was 74.4 lb. per sq. in. and the mechanical efficiency was 80.5 per cent. The average compression in the main cylinders was 412 lb. per sq. in. with a maximum peak of 455 lb., as illustrated by Fig. 8. Air for scavenging requires a pressure of only 2 lb. per sq. in.

Hot Bulb Engine Used for Air Compressors

In addition to the large Nobel engine driving the ship, there is provided a 2-cylinder hot-bulb engine, which drives air compressors used to replenish the starting air supply when more than the usual number of maneuvers is to be made.

Unlike the solid injection engines with straight atomization, relying on a finely divided spray and on the heat generated by compression to ignite the fuel charge, the hot-bulb engine depends on the heat radiated from the uncooled part of the combustion chamber to fire the injected fuel. Compression in these engines is kept low —approximately 150 lb. per sq. in., and the jet issuing

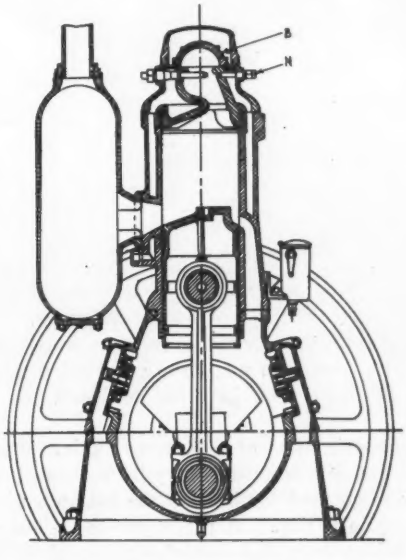


FIG. 9. CROSS SECTION OF GAMMA ENGINE SHOWS PECULIAR SHAPE OF COMBUSTION CHAMBER

from the spray nozzles is poorly atomized, if atomized at all. The practical advantage of the latter feature lies in the fact that the construction of the fuel pump may be light and simple.

Figure 9 shows a cross-section of the Gamma engine. It is of the crankcase, port scavenging, 2-cycle type. The uncooled part of the combustion chamber is separated from the water cooled section by a ridge which, together with the location of the neck, prevents a rush of air from the cylinder directly striking the hot bulb B and cooling it excessively when running at light loads.

Fuel is injected in a solid stream through the nozzle N, and impinges against the water cooled plug located opposite. The jet is thereby finely divided, mixes with the surrounding hot air and ignites. The shape of the combustion chamber allows the engine to run at all loads without the aid of water injection or an expansion ring.

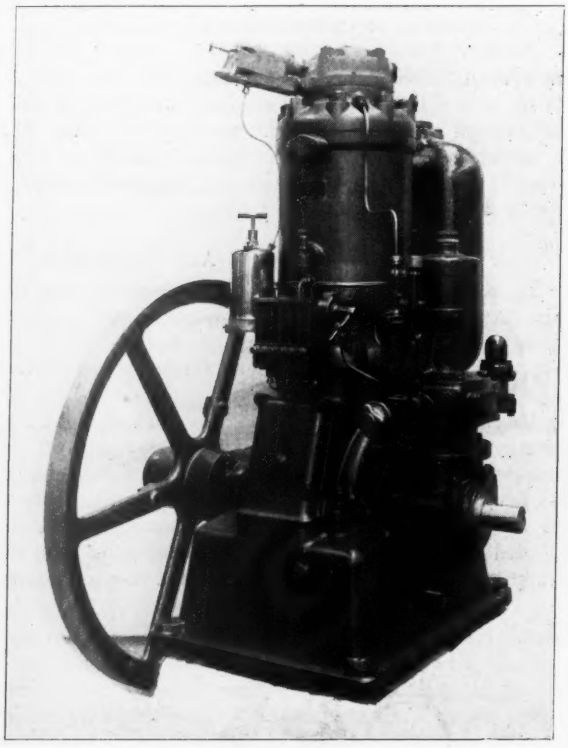


FIG. 10. SINGLE CYLINDER GAMMA ENGINE WITH BLOW TORCH FOR HEATING HOT BULB, SHOWN AT THE UPPER LEFT

The air valves for crankcase scavenging are attached to the covers. They are made of leather disks backed by sheet steel and held in place by spiral springs. It should be noted that the air is not drawn in directly from the outside but comes from underneath the bed plate through channels in the covers, in order to lessen the cylinder noise.

An isometric view of a Gamma engine is shown in Fig. 10. The different parts may be easily distinguished. The blow torch used for heating the hot-bulb when starting the engine is shown at the upper left. The governor shaft is driven from the crankshaft through bevel gears, actuates the fuel pump and the water circulating pump and is shown at the right.

Whaley Constant Pressure Oil Engine Presents New Features

OIL ENGINE practice has just witnessed several radical changes in the usual design in the new Whaley engine invented by William B. Smith Whaley, designed by Charles A. Muller, and built by the Sun Shipbuilding Co. at Chester, Pa.

Ninth of a series built during the past several years for the purpose of perfecting a new power cycle, it is described as a single-acting, four-cylinder, two-cycle oil engine, designed to develop 750 hp. It is a vertical reversing engine, conventional in design, though following in many respects the best steam-engine practice. It is distinguished from other heavy-oil engines by the fact that the cylinder clearance, at the time of fuel injection, is opened by a piston valve to communicate with a static air receiver having many times the capacity of the cylinder clearance. The piston valve to the static receiver is open as long as the fuel is being injected.

The Whaley engine has the usual form of port scavenging supplemented by high-pressure scavenging and supercharging through the top of the cylinders. The last two operations are carried out with air at a pressure of about 45 lb. per sq. in. The air pumps for the superscavenging and supercharging operation are contained in the lower part of the power cylinders. There is a supplemental scavenging air pump formed in the upper part of the frame in which operates a piston placed on top of the crosshead. Two cylinders are cast in block with a valve chest between. The air from the pumps just described is used either in direct line or is transformed through the ports in the valve chest to the opposite cylinder.

Air Controlled by Link Motion

Air is controlled by piston valves, one working inside the other and both being actuated by links similar to those used on locomotives and reversing marine steam-engines. By this link motion the opening of the piston valves is made to synchronize to the period of fuel injection in such a way that, for practical purposes, combustion takes place during the entire time that the valve is open. The practical effect in the operation of the engine will be that fuel will be supplied to the point of cutoff of the piston valve, which will be open for the power necessity of the engine. The resultant diagram will, therefore, be similar to that of a steam engine so far as the admission and point of cutoff are concerned. The main purpose of the clearance reservoir is to maintain the maximum working pressure desired, which, in the case of the present engine, is 350 lb. per sq. in. As this is the normal compression pressure of each working cylinder, it is also the normal pressure for the receiver or reservoir.

Under normal running conditions, no variation in pressure is expected no matter what the conditions of loading and fuel injection may be. In floating the receiver on the compression space, there will be but little transfer of air, heat or pressure through the valves. The receiver serves as an absorber in case of any rise in pressure in the cylinder through any cause whatever. By an ingenious arrangement of the valves, the compression space part is made to serve successively for the introduction of the super-scavenging and supercharging, and to establish communication with the reservoir or receiver during the combustion period.

Novel Fuel Pumps and Valves

Fuel pumps and fuel admission valves have a novel arrangement. The fuel pump is placed on top of the valve chest and is driven directly from the valve stem. The pumps deliver the charge of oil for each stroke directly into each individual fuel valve, no piping whatever being employed. The pressures are between 4000 and 8000 lb. per sq. in. The action of the pumps synchronizes with the action of the valves, both being operated from the same valve stem, thereby assuring the maintenance of relation between fuel injection and duration of the valve opening to cutoff. Because of this construction, there will be practically no rise in pressure in the cylinders or in the system beyond that due to compression.

Fundamental Action Shows Radical Changes

The fundamental action of the Whaley engine is entirely different from that of any of the present oil or Diesel engines. All other present-day engines operate with a trapped charge of air which is confined in closed compression space into which the fuel is injected, and there is always a rise in pressure after combustion takes place. In the Whaley engine, even early timing of the fuel admission will cause no appreciable pressure rise above the capacity of the pressure valves into the receiver.

Maintaining the maximum pressure to a definite figure allows the carrying out of a program for the design of relatively light-weight oil engines. It is expected that the Whaley engine will weigh less than 100 lb. per hp., a figure which represents a substantial improvement over current practice. Also, due to the maximum pressure principle, the Whaley engines, for all sizes of power, can be built at approximately the same weight per horsepower, as is the case with the steam engines. This means that the weight of less than 100 lb. per hp. will apply to Whaley engines of all sizes. This feature will make the development of the Whaley engine much more valuable as an economic factor, the larger the units are built, especially since with the present Diesel and heavy-oil engines, weights increase progressively as the power to be delivered increases.

Parish & Tewksbury, Inc., New York, has had executive charge of this development since February, 1924.

100-Ft. Dam to Be Built for Destruction

RAISING $70,000 to build a concrete dam so as to destroy it and see what happens is a rather unusual procedure, but this is the very considerable undertaking in which a special committee of the Engineering Foundation is now engaged. The dam, about 100 ft. high, will be erected on Stevenson Creek, a tributary of the San Joaquin River, about 60 mi. east of Fresno, Cal. It will have abutments excavated in the solid rock, will be 7 ft. 5 in. thick at the bottom, tapering to 2 ft. at the 30-ft. level which thickness will be continued for the rest of the height. Upstream radius will be uniform at 100 ft.

Testing an actual structure of this size to destruction is said to be something new in engineering effort and it is expected to settle science problems centuries old by the results. The dam will first be built to 60 ft. and after making a complete series of tests, additions will be made, 10 ft. at a time, with tests made after each addition, until a height of 100 ft. is reached. Water supply, under complete control, will be obtained from the main supply of the California Edison Co. through a conduit and will be independent of rain or snow fall.

Special instruments will be prepared for measuring stresses, taking temperatures and noting the slight movements of the dam during construction. These will be carefully tested and calibrated by the Bureau of Standards at Washington, D. C., before being taken to the dam. Foundations are now being prepared so that it is expected that placing of concrete will begin in October. The tests at the 60-ft. level are expected to take a year.

Unusual co-operation has been secured, as the investigation is being made by the American Society of Civil Engineers in conjunction with the U. S. Bureau of Reclamation, the states of California and Oregon, San Francisco, Los Angeles County, power companies, irrigation districts, universities and individual engineers in America and Europe.

Natural conditions are remarkably favorable, for the dam is to be in a rough, rocky gorge where no damage could result, if the dam should break under tests. Also ample water supply is at command, under absolute control. As the size exceeds that of some existing arch dams, the results will be immediately applicable to practical construction and results will be useful in designing and building other concrete structures, particularly other types of dams and arches for other purposes.

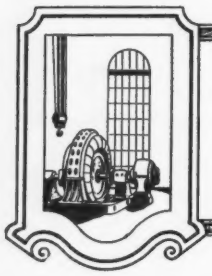
Upwards of $100,000 will be spent in the course of the construction and tests, but the expenditure will be well repaid by the knowledge gained.

Aid for Delivery of Fuel Oil

AT THE heating plant of the Great Western Power Co., located in the down town section of San Francisco, the storage supply for oil is such that it is necessary to deliver a tank load of oil every 90 min. during the day. For the purpose of keeping automobiles from parking near the intake, special traffic signs have been installed as shown in the accompanying photo.

NO PARKING SIGN AIDS FUEL DELIVERY

One of the signs says "NO PARKING OIL INTAKE" and the other says "FOR OIL TRUCKS ONLY NO PARKING."



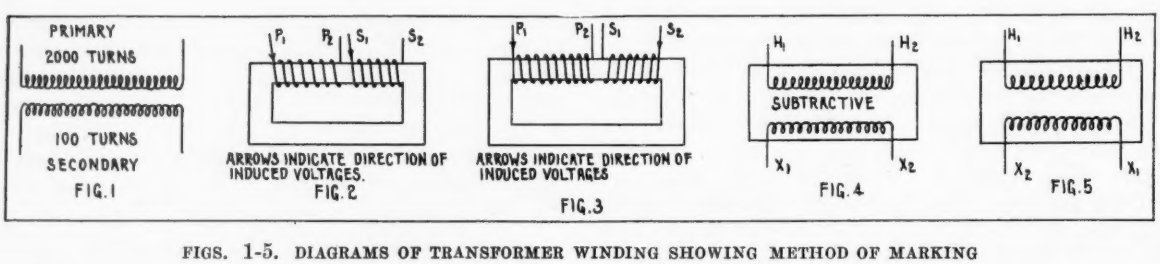
ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Transformer Connections

PART I. PRELIMINARY CONSIDERATIONS. NOMENCLATURE. METHODS OF MARKING TERMINAL LEADS. BY V. E. JOHNSON

WITH THE widespread use of alternating current in industrial electrification, it has become more and more necessary for the plant engineer to familiarize himself with the principles and proper application of transformers. The numerous ways in which transformers may be connected complicates the problem and requires as a basis for intelligent engineering, a fairly broad understanding of the underlying principles.

It is the object of this article and others that are to follow, to discuss the proper connections of transformers under normal and abnormal conditions, and to point out the most desirable method of meeting requirements imposed by my particular problem.



FIGS. 1-5. DIAGRAMS OF TRANSFORMER WINDING SHOWING METHOD OF MARKING

NOMENCLATURE

There are certain terms which apply to every transformer and which must be defined. The standardization Rules of the American Institute of Electrical Engineers are clear and we can do no better than to quote from them.

Due to the fact that the same transformer can be used to step the voltage either up or down, it is evident that the terms "primary" and "secondary" are not at all synonymous with "high voltage" and "low voltage" as applied to the windings. Therefore the Rules distinguish between them as follows:

The terms "high voltage" and "low voltage" are used to distinguish the winding having the greater, from that having the lesser number of turns. The terms "primary and secondary" serve to distinguish the windings in regard to energy flow, the primary being that which receives energy from the supply circuit.

Similarly, the term "ratio" can have two meanings, and the Rules refer to these as "voltage ratio" and "transformer ratio," the former being based on the ratio between the primary and secondary terminal voltages, and the latter on the ratio between the number of turns in the high voltage and low voltage windings. The "transformer ratio" as defined above is evidently a constant for any given connection, while the "voltage ratio" varies with the load. This variation with load is comparatively small and is proportional to the "regulation" of the transformer.

"Regulation" is defined as the ratio of the rise of secondary voltage from full load to no load, at constant impressed primary voltage, to the secondary terminal voltage at full load. For example, if in a certain unit the secondary voltage rose from 100 at rated load to 102 at no load (with constant impressed primary voltage) the regulation would be 2/100, or as it is commonly expressed, 2 per cent.

Transformers are rated in kv.a. output, which equals for a single-phase unit volts $\times$ amp. $\div$ 1000, and for a three-phase unit volts $\times$ amp $\times$ 1.73 $\div$ 1000. The kilowatt rating would be obtained by multiplying either of the preceding fractions by the power factor of the load. The A. I. E. E. rules state that a "transformer must be capable of delivering the rated output at rated secondary voltage, while the primary . . . is increased . . . to whatever value is necessary to give rated voltage." The amount of this "necessary increase" depends upon the regulation of the transformer.

SINGLE PHASE TRANSFORMATION

The simplest case of single phase transformation is that shown in Fig. 1. The turn ratio is evidently 2000/100 or 20 to 1. The rating of the secondary determines the rating of the unit and is assumed to be 100 v. at 10 amp. or 100 $\times$ 10 $\div$ 1000 kilovolt-amp. If the regulation is 2 per cent, a primary impressed terminal voltage of 2040 will be required to maintain full secondary voltage at the rated load. This corresponds to the definition previously given, for if the primary be kept at this value, and the secondary load removed, the voltage would rise to 102, an increase

of 2 per cent. The voltage ratio at full load is, by definition, 2040/100, while at no load it is 2040/102 which is equal to the turn ratio.

Voltage Relations and Polarity

For the sake of clearness, Fig. 2 has been drawn, which shows the coils of a transformer placed in line on the same leg of the core and wound in the same direction. A flux flowing through the core will therefore affect both the primary and the secondary windings in the same manner, and will set up in them induced voltages in the relative directions indicated by the arrow heads, namely from P-1 to P-2 and from S-1 to S-2. The induced voltage in the primary coil opposes the impressed voltage, so that it follows that the latter must be in the direction P-2 to P-1 or against the arrow points.

The secondary load current would flow in such a direction as to oppose the primary flux, or to state the matter more accurately, the primary and secondary ampere turns oppose each other.

Assume for example that the primary coil and secondary coil are wound in opposite directions as in Fig. 3. An impressed voltage in the direction P-2 to P-1, would as before induce a voltage from P-1 to P-2, and from S-2 to S-1. The secondary current would flow from S-2 to S-1 and the ampere turns would oppose the primary.

Comparing Fig. 2 and Fig. 3, it will be noted that in both sketches the induced voltages are in the same direction in the half turns which are towards the reader, namely from top to bottom, and that the only essential difference is the relation between the flow of secondary current and the lettering of the secondary leads. If the leads in Fig. 3 were reversed, or if the lettering were reversed (which amounts to the same thing) the two sketches would be identical.

If the units above were to operate alone, the marking of the leads would be of no consequence, but when several transformers are to operate together, it is evidently important that the operator know their meaning and use. Unfortunately there is no fixed rule concerning the marking of leads on apparatus built by different manufacturers, or indeed on apparatus built by the same manufacturer, and this makes it necessary that the so called "polarity" of a given unit be known before the significance of the symbols can be understood. The Power Club and the A. I. E. E. have set certain standards concerning the definition of polarity and the principal manufacturers adhere to them. Therefore with a given set of markings and polarity, it is possible to connect two units with certainty that they will, if otherwise suitable, operate together.

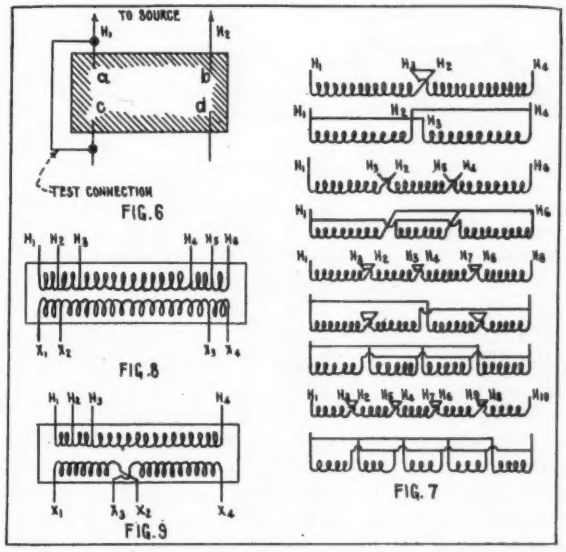
If P-1 in Fig. 2 were joined to P-1 in Fig. 3 and P-2 to P-2, it is evident that the proper secondary connection would be made by joining S-1 in Fig. 2 to S-2 in Fig. 3, for this is the direction in which the currents would tend to flow. If P-1 were joined to P-1 as before, but S-1 were connected to S-1, a short circuit would result.

In order to simplify lead markings, the Rules provide that the letter H be used to designate the high winding terminals brought out of the tank, and that similarly the letter X be used to designate the external leads of the low voltage winding. To these letters, numbers are to be added (H1, H2, X1, X2, etc.), and these are to be such that two units may be operated in parallel by connecting similarly marked leads together, provided, of course, that the other characteristics permit this.

The Rules further provide that this lettering and numbering be so applied that when H1 and X1 are connected together and voltage applied to the transformer, the voltage between the highest numbered X lead and the highest numbered H lead shall be less than the voltage of the full high voltage winding. Furthermore, when a transformer is so marked the polarity will be designated as "subtractive" when H1 and X1 are adjacent, and additive when H1 is diagonally located with respect to X1. The H1 lead should be brought out on the right hand side of the case when facing the high voltage side.

Figure 4 shows a transformer having subtractive polarity, and marked according to the foregoing rules, while the unit in Fig. 5 has additive polarity.

If the foregoing marking rules be applied to Figs. 2 and 3, substituting H for P and X for S, it will at once be seen that Fig. 2 has its leads correctly marked, for if P-1 be joined to S-1 the voltage between P-2 and S-2 will be approximately equal to the algebraic sum of the primary and secondary voltages, and that this will in this



FIGS. 6-9. TRANSFORMER DIAGRAMS

Fig. 6. Method of testing for proper polarity. Fig. 7. Multi-coil windings of transformers arranged in various ways. Fig. 8. Transformer with single coil windings and with taps brought out on both high and low sides. Fig. 9. Unit having the high side tapped and low side arranged for series parallel operation.

case be their arithmetical difference. For example, if P-1 to P-2 be 2000 v. and S-1 to S-2 be 100, P-2 to S-2 will be 2000—100, or 1900 v., which (in accordance with the Rules) is less than the voltage of the high winding. If P-1 and S-1 were brought out of the tank as in Fig. 4, the polarity would be subtractive while, if the leads were crossed and brought out as in Fig. 5, it would be additive.

If, on the other hand, a similar substitution of markings be applied to Fig. 3 it will be seen at once that the Rules have been violated, for if P-1 be connected to S-1, the voltage between P-2 and S-2 will be the arithmetical sum of the coil voltages, or under the values assumed above, 2100 v. However, if H1 and H2 be substituted for P-1 and P-2 respectively, and X1 and X2 for S-2 and S-1 respectively, the Rules will have been followed, and parallel operation can be obtained by connecting similarly marked leads in Figs. 2 and 3.

On transformers manufactured in accordance with the Rules, the nameplate contains full information as to the arrangement of the leads. The information is sometimes etched on a brass plate and at other times is contained on a blueprint mounted under glass or celluloid in a suitable frame.

In the absence of proper name plate information as to the connections of a given unit, these may be determined by a test as follows. Assume a unit as in Fig. 6, having its primary and secondary leads unmarked. It is usually possible to distinguish the high voltage and low voltage windings by inspection, but if this is not possible a ratio test (using low voltage) will be necessary. The right hand high voltage lead, facing the high voltage side of the tank, should be marked H1 and the other lead H2. With a single coil primary this is all the marking required, but if there are several coils, or several taps, with external leads, tests must be made to determine their relation to one another. Under such conditions the right hand lead will be marked H1 as before, but the other end of the full winding would be marked with H4, H5, etc., depending on the number of taps, the highest H number being the full winding terminal. Referring to Fig. 6 (a) would be marked H1, and (b) H2 (or a higher number).

The adjacent terminals (a) and (c) should next be connected, and voltage applied to the transformer, either to the high or low voltage sides, depending on which is the more convenient. In the figure the source of power is shown connected to the high voltage side. The voltage from (a) to (b) should be read simultaneously with that between (b) and (d). If the former value is greater the transformer has subtractive polarity and the lead (c) should be marked X1. If the voltage from (b) to (d) exceeds that between (a) and (b) the polarity is additive, and the lead (d) should be marked X1.

Example: If voltage (a) (b) is 125 v. and voltage (b) (d) is 112 v. the lead (c) should be marked X1.

Multi-Coil Windings and Voltage Taps

The previous discussion has dealt largely with units having single coil high and low voltage windings without taps. Commercial transformers are seldom built this way, as provisions are usually made for operation at two or more voltages on the low as 115/230, or for voltage adjustment taps on the high side. By dividing either winding into a number of coils arranged for series, parallel, or series-parallel, a wide range of conditions may be met. For example a two coil winding in parallel would have a normal voltage of 6600, while in series the rating would be 13,200. Similarly, a four coil winding, all in series, would give say 460 v.; all in parallel 115 v., two in series, in parallel with two in series, 230 v. A five coil winding would give say 2300 v. in series, and 460 v. in parallel. Figure 7 shows a number of typical multi-coil windings arranged in various ways. These are marked as being high voltage coils, but X could be substituted for the H without affecting the correctness of the diagrams. The leads in the diagram are marked according to the Rules, but if X is substituted it must be located according to the polarity of the transformer, assuming that all of them are, in both cases, external.

Various operating conditions require transformers in which the primary or secondary voltage can be varied within small limits by means of taps which cut out a number of turns from either winding. These are referred to as voltage taps, and are specified in percentages of the full coil voltage, or normal line potential. Thus, a 2300-v. winding with two 5 per cent taps would give 2185 and 2070 as operating voltages. With four 2½ per cent taps the voltages would be 2245, 2185, 2130 and 2070.

On single coil windings, the voltage taps may be brought out at either end, though it is customary to bring half of them out at each end, in order to maintain electrical and mechanical symmetry. In multi-coil windings it is necessary to bring them out in such a manner that the various sections may be operated in parallel, which necessitates that each section have the same number of taps. For example, a 2300/1150 v. winding with four 2½ per cent taps, would have two taps on each half. This would actually give two 5 per cent taps when connected in parallel, as 2½ per cent of 2300 would equal 5 per cent of 1150.

Taps are classified as "full capacity" and "reduced capacity," the former being those on which the unit may be operated at rated kv.a. capacity.

Figure 8 shows a transformer having single coil windings, and taps brought out of the tank on both the high and low sides. The markings of the leads is in accordance with Power Club Rules. Figure 9 is a unit having the high side tapped, and the low side arranged for series parallel operation. Figure 10 shows the actual appearance of a transformer such as that in Fig. 9. The low side leads are connected as shown for three wire 110/220 v. operation, and the load connected between the middle lead and the two outsides.

Figure 11 shows a typical terminal block for a low voltage transformer. On high voltage units it is impossible to get sufficient spacing on a single block, and it is therefore common practice to bring the leads out to terminals mounted on impregnated wooden supports. Figure 12 is an actual connection diagram used with a transformer having a connection block as in Fig. 11, while Fig. 13 is an actual diagram for a high voltage unit.

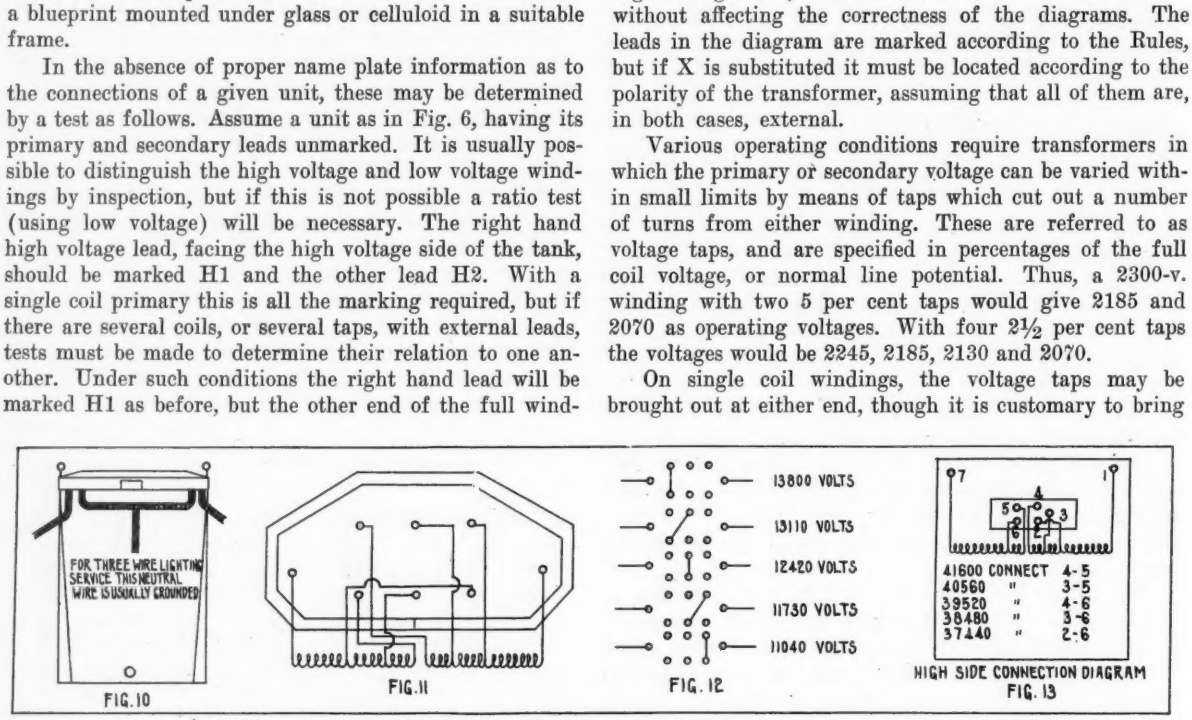


FIG. 10 FIG. 11 FIG. 12 FIG. 13

FIGS 10-13. METHODS OF BRINGING OUT TERMINALS. DIAGRAMS OF CONNECTION BLOCKS

Principles of Power Factor Correction

Use of Synchronous Condenser to Cut Down Losses From Useless Current in the System. By Chas. G. Green*

IN ORDER to secure the greatest economy, both in first cost and operation of alternating current generators, transmission lines and connected motors, it is important that the power factor of the system be kept as nearly unity as possible. If we have a number of induction motors and transformers on the line, it is not easy to maintain a high power factor, as explained in the July 1 issue, page 701, especially if these devices are carrying light loads.

As explained in the issue of Aug. 15, page 849, a synchronous motor, sometimes called a synchronous or rotary condenser, can be made to compensate, partly or entirely, for the effect of inductive apparatus in the circuit, by overexciting the field of the synchronous motor and causing what is known as condensive reactance which will neutralize the effect of inductive reactance.

Cause of Useless Current

Power factor, which is the cosine of the angle between the voltage and current in an alternating current circuit, is low when there is great difference in phase between the voltage and the current. The current is said to be out of

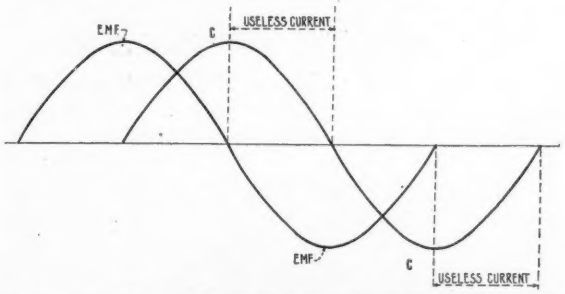


FIG. 1. USELESS CURRENT IS THAT FLOWING AFTER E.M.F. HAS REVERSED

phase and is usually lagging. That part of the current which flows between the time when the voltage has dropped to zero and the time the current reaches zero is often called wattless current, but this is a misnomer, for there can be no current without electric pressure to force it along and energy will always be used up in overcoming the resistance of the circuit.

In the case of wattless current, it is the e.m.f. of self induction which drives the current during the "wattless" period and power is used up in the circuit. It is not, therefore, wattless current, but useless current and the power used by it is wasted so far as doing any work is concerned. It puts extra and wasted load on the generators without accomplishing anything useful and, in fact, reduces the capacity of the system for useful work.

After the limit of a system for supplying and carrying current has been reached with a low, lagging power factor, installation of one or more synchronous condensers may be made to raise the power factor and thus make possible the delivery of more useful energy with the same current flow, by reducing the useless current or, in other words, by decreasing the lag between voltage and current. This is done by introducing a condensive reactance into the circuit which opposes the inductive reactance, permitting the current and e.m.f. to vary more nearly in harmony, as if there were little or no inductance in the system. The method and principle are more fully explained in the August 15th issue, page 849.

Capacity or size of the synchronous condenser to be

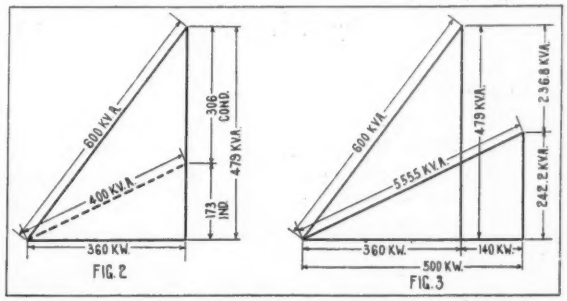


FIG. 2. CONDENSIVE REACTANCE USED TO NEUTRALIZE INDUCTIVE REACTANCE, SYNCHRONOUS MOTOR UNLOADED
FIG. 3. RELATIONS OF USEFUL AND USELESS ENERGY FOR SYNCHRONOUS MOTOR TO CORRECT POWER FACTOR AND CARRY MECHANICAL LOADS

used should be determined from the conditions in the system and the results desired.

Size of Condenser Needed

For example, suppose that a system is operating with a load of 360 kw. and power factor of 60 per cent and that we wish to install a condenser to raise the power factor to 90 per cent, the motor to carry no mechanical load.

Dividing the power load, 360 kw., by the power factor, 0.60, gives the kv.a., 600, and the useless component is the square root of ($600^2 - 360^2$) or 479 kv.a. In order to raise the power factor to 0.90, the capacity of condenser needed may be found as follows:

With power factor 0.90, the apparent load or kv.a. needed to carry the useful load is $360 \div 0.90$ or 400 kv.a., and the useless component will be the square root of ($400^2 - 360^2$) or 173 kv.a. The condenser must supply the difference between these two useless components or $479 - 173 = 306$ kv.a. at power factor 1.00, so that the capacity should be 300 kw.

If it is desired that the machine installed should carry mechanical load of 140 kw. in addition to correcting the power factor, it must have capacity to meet both requirements. The total power component of the system is now $360 + 140 = 500$ kw. The kv.a. for this component will be $500 \div 0.90$ or 555.5 and the useless component is the square root of ($555.5^2 - 500^2$) or 242.2 kv.a. The condenser must then supply a useless component of 479 — 242.2 or 236.8 kv.a. in addition to the power which it furnishes, 140 kw. Its rating must therefore be the square root of ($140^2 + 236.8^2$) or 275.2 kv.a., which would call for a 275-kw. synchronous condenser.

In all the computations, round numbers and approximate calculations have been used, hence closer figuring might show that a slightly smaller machine would serve

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the purpose, but the method for determining the capacity would be as shown.

Synchronous condensers, like synchronous motors, are best adapted for loads that are fairly continuous and steady. Frequent starting should be avoided. Loads most desirable are pumps, compressors, fans and the like, which are operated over long periods with slight changes. When starting up, it is advisable to carry only a part of the load, usually less than 1/3 of full load.

Experience on the Road

By E. L. Doty

IN CASE of accident or trouble on an electrical system the service engineer usually arrives on the scene after the trouble has occurred and he sometimes finds it extremely difficult to determine the cause of the interruption or breakdown. Operators or attendants either do not know how the trouble started, or believe it wise not to tell what they do know or suspect. The engineer must, therefore, have imagination and ingenuity as well as skill in the use of testing equipment, for frequently there is little testing that can be done.

Several years before protective relays had been developed to guard against almost any possible abnormal condition in transmission and distribution circuits, a young engineer was detailed to investigate the cause of an accident which proved, for a time, to be exceedingly puzzling. The representative of the operating company who called the service department on the long distance telephone was too much excited to be able to give a coherent statement concerning what had happened. He stated that lamps had blown out of sockets and that instrument wires had burned off, and reported that the plant was entirely shut down and that something had happened in the 60,000-v. transformer station.

Although the service department is not actually ubiquitous, an expert wireman who was within 10 mi. or so of this isolated plant, was instructed by telephone to secure an automobile and proceed to the scene of trouble immediately. An engineer was also sent from the district office by the first train. The telephone report received was found to have been in no wise exaggerated. Lamps had been blown apart and wiring had burned off. It seemed evident also that an abnormally high voltage disturbance had occurred in the power transformers. Tests determined that these transformers were not grounded nor short-circuited and there had been no line failure.

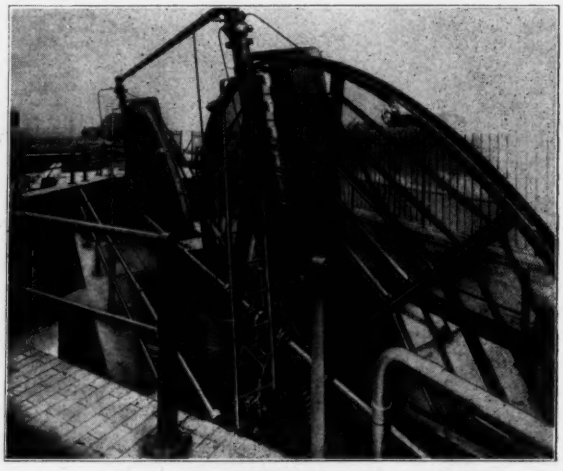
The operator stated that, although he was in the transformer room when the "explosion" occurred, he was not switching the transformers in or out, and it was found that the plant had been operating very satisfactorily just before the accident occurred. The engineer not only did everything that seemed possible to determine the condition of the transformers but he examined the switching apparatus, the lightning arresters and other equipment that might by any chance furnish some clue to the cause of the trouble. He also questioned the operator in detail concerning events preceding, at the time of and after the disturbance but could learn nothing upon which to base a conclusion.

At the power plant 50 mi. or more away, the transformers were known to be connected delta low-tension and star high-tension, and those in this station on the receiving end were connected star high-tension and delta low-tension so there were possibilities of high voltage under certain conditions in case of a ground; but as far as could be discovered there had been no ground.

Late in the day, the engineer was standing on top of one of the transformers speculating on the strangeness of the situation and making, from this point of vantage, a final survey of the station high-tension wiring, when his glance fell on the hook-stick used to operate the disconnecting switches located between the lines and the lightning arresters. This stick was standing in a corner and the afternoon sun was reflected from the funnel-shaped copper shield located well up on the stick, to which a grounding chain was connected. Some spots on this shield, that looked like burns, attracted the attention of the engineer and he immediately started to investigate. He found that the spots were holes burned through the copper shield, apparently by current. He tried the hook-stick in the disconnecting switches above the low equivalent lightning arresters and then he saw the answer to his problem; for if the individual using the hook-stick was careless, the copper shield to which the ground chain was attached might come in contact with the spark gap at the top of the lightning arrester, about 4 ft. below the disconnecting switch and connected directly to it by a heavy wire. The burned spot in the shield fitted the spark-gap sphere perfectly.—The Electric Journal.

Self-Cleaning Water Screen

USE OF LARGE volumes of condensing water from rivers and canals is an essential requirement in the operation of the modern steam power plant. In order to remove floating leaves, twigs, fiber and other solids from the water, Messrs. Brackett & Co. have recently introduced a rotating screen. It consists, essentially, of a steel frame, made in the form of a disc and covered with a heavy wire screen. This disc is mounted on a shaft which is rotated slowly. Rubbish in the water is caught on the face of the screen and by the rotation of the disc it is elevated out of the water until it reaches the level of the cleaning jets where it is thrown off above a catch board and washed into a trough.



RUBBISH IS BROUGHT ABOVE WATER SURFACE BY ROTATION OF SCREEN

Detroit Edison Builds Switch Station in a Day

AFTER SWITCHING STATION AT SUPERIOR HYDRO PLANT OF DETROIT EDISON CO. HAD BEEN DAMAGED BY LIGHTNING, A TEMPORARY OUTDOOR SWITCHING STATION WAS COMPLETED IN 26 HR.

TWENTY-SIX HOURS after a bolt of lightning struck the 23,000-v. line leading from the Superior plant of the Detroit Edison Co., on the Huron River between Ann Arbor, Mich., and Ypsilanti, Mich., causing an explosion and completely disabling the station, the operating force and overhead lines department had completely restored service and had in operation a complete 23,000-v. outdoor switching station to replace the damaged one. The story of how this was done, as told in the Detroit Edison Synchroscope, forms an inspiring tale of resourcefulness, sound engineering judgment and devotion to duty that should interest every power plant engineer.

FIG. 1. LIGHTNING CAUSED EXPLOSION OF VAPORIZED SWITCH OIL IN SUPERIOR SWITCH HOUSE, PRODUCING THIS RESULT

Of the five hydro-plants of the Detroit Edison Co. on the Huron River, the one at Superior is the key plant, as switching connections are centered there and there is a 120,000-v. stepdown substation fed by the lines from Trenton Channel and Marysville.

At 7:04 p. m. on July 3, a bolt of lightning struck the 23,000-v. line leading from Superior to Ypsilanti and the automatic oil switch on this line was unable to stand up under the duty imposed on it. The switch opened but failed to break the arc, which continued in its path, vaporizing the oil. The resulting explosion blew out the brick walls of the switch house, as much as 16 in. in several places, destroyed windows and doors, and broke concrete bus structures and baffles. Other switches in the switch house tripped out automatically and the station was dead, stopping service to Ann Arbor, Ypsilanti and other towns. Figure 1 shows the interior of the switch house after the accident.

Under the direction of Superintendent Geo. E. Lewis, the work of restoring service was begun almost immediately after the explosion. The hydro plants at Barton and Argo were loaded to full capacity, and power was supplied to Argo through another line, restoring service to towns west and north of Ann Arbor. Service was restored in the north half of Ann Arbor in 11 min. and in the whole city in about 30 min.

Restoring service to Ypsilanti was a little more difficult, since the paper mill hydro plant there was out of commission because its exciter is electrically driven; the Geddes plant also was involved in the trouble. By means of jumpers the Superior-Wayne line was connected to the north line from Superior to Ypsilanti and service was

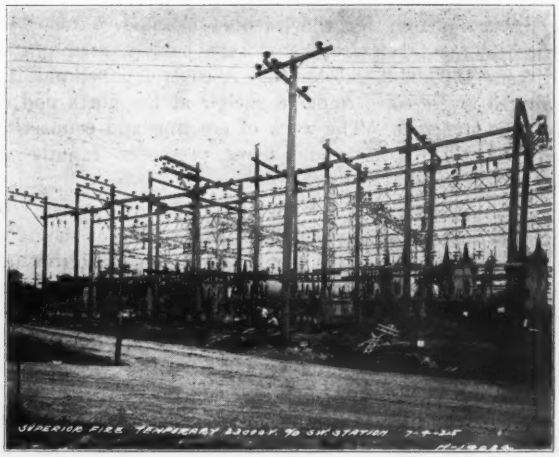


FIG. 2. TWENTY-SIX HOURS AFTER THE ACCIDENT, THIS TEMPORARY SWITCHING STATION WAS READY TO OPERATE

resumed in Ypsilanti 2 hr. and 13 min. after the accident.

TEMPORARY OUTDOOR SWITCHING STATION IS PLANNED

Meanwhile some of the linemen cut the Superior plant clear from all overhead connections and connected the four lines at this point together and to the 23,000-v. side of the 120,000-v. stepdown transformer. This provided plenty of power, but could only be regarded as a makeshift arrangement, since trouble on any one of the four lines would involve all the others. Accordingly it was decided to proceed with the construction of a temporary, outdoor, wood pole switching station, located next to the 120,000-v. outdoor substation, to replace the damaged Superior switch house.

The plan was a bold one. The work would have to be carried on all night by the light of truck lights and lanterns. It was no easy matter to round up the overhead line force, as many of them were just starting on their July 4th holiday. In spite of the willingness of the men, they were tired already, as they had then worked a full day with a couple of hours of emergency overtime. Equipment and material would have to be trucked from Detroit, 40 mi. away; the next day was a holiday with supply houses closed and workmen off duty. There were no plans or blue prints and the design of the station would have to be a cut-and-try matter. In spite of all these difficulties, it was decided to go ahead, and work on the new temporary switching station was begun a little over two hours after the accident.

Arrangements were made with the Detroit office to send out oil switches, line material, poles and a portable air compressor and drills to chip away old masonry that was found while digging holes for the poles. All through the

night of July 3, 60 linemen worked, erecting poles. Lumber for cross-framing was secured in Ypsilanti and timbers that had been used in shipping machinery and were stored at Superior were pressed into service. The linemen worked unceasingly, cheerfully abandoning plans for a holiday. Food and coffee were supplied and eaten standing. Towards morning one of the linemen fell asleep while standing up and eating a sandwich. But on the morning of July 4, 21 poles had been set, overhead framing was in place, pins and insulators set and copper bus wires and connections run. At 11 a. m. the first load of outdoor oil switches arrived from Detroit and 20 electricians, aided by 20 men sent from Detroit, began putting them in place.

Direct current for the solenoid-operated, outdoor oil switches was taken from a storage battery used in the adjacent 120,000-v. substation. A control panel was improvised and erected under a shelter at the north end of the new structure. The work of erecting and connecting switches, control leads and panel proceeded rapidly all day on July 4.

As completed, the new switching station consisted of eight switches, one between the 23,000-v. side of the 120,000-v. substation and the new station, one section switch between the busses of the new station and five line switches. All these switches were operated from the control panel. The completed station appeared as in Fig. 2. Both of the illustrations used with this article were furnished by the Detroit Edison Synchroscope.

Connection and testing of switches, filling of the tanks with oil and final adjustments were completed, and at 9:38 p. m. on Saturday, July 4, the operator at Superior reported to the system operator at Detroit that a new 23,000-v. outdoor switching station was ready to go into commission to replace the switch house of the Superior hydro-plant that had been damaged by lightning at 7:04 p. m. on July 3, 26 hr. previously.

Standard Connections for Electrical Apparatus

AMERICAN ENGINEERING Standards Committee announces the approval as American Standard of a system of connections and markings for electric power apparatus. The standard is the result of a revision of the work of the Electric Power Club which has been developed over a period of years. The most important part of the revision, which has been carried out by a sectional committee upon which all interested bodies are represented, under the sponsorship of the Power Club, has consisted in systematizing the work into a general plan which not only takes care of present needs, but also provides sufficient flexibility for future developments.

Previously, great confusion existed, as each manufacturer was using his own markings. The system as now elaborated assigns a characteristic letter to each type of connection. Subnumbers are used to differentiate between the various terminals of each class. These letters were chosen wherever possible so as to conform to the practice of many years and cause as little confusion as possible for those who have to make practical use of the diagrams presented.

The fundamental scheme is simple, and completely covered on a single page. The remainder of the standard illustrates the methods of applying such markings to the more commonly used types of apparatus. These key diagrams are intended primarily for the use of engineers and draftsmen in correctly placing the required marking on the working diagrams of connections or wiring and for the use of engineers and wiremen installing the apparatus. Some illustrations of actual working diagrams are given to show how these markings are used commercially.

As only a relatively small part of the alphabet has been used, enough letters remain to cover any new varieties of apparatus that may be developed in the future.

This standard represents the combined effort of a large number of engineers, and has stood the test of several years practical application on a large scale. This system of connections and terminal markings is being submitted to the International Electrotechnical Commission for adoption as an international standard.

Measuring Strains in Concrete Structures

SOME TIME ago the Bureau of Standards, Department of Commerce, brought out what is known as an "electric telemeter" for measuring changes in the length of structural members produced by variations in the load upon the structure. The operation of the telemeter depends upon the variations in resistance to the passage of an electric current of a stack of carbon disks. This is the same principle as that employed in the microphone in the transmitter (the part we talk into) of the telephone. There is, therefore, nothing new in the principle employed, but the Bureau was the first to apply this principle to a precision measuring instrument.

Recently a new use has been found for this device in the measurement of the strains in mass concrete. For this purpose a special cartridge has been designed which houses the stack of carbon disks and which is embedded in the concrete at the point where the measurement is to be made. Wire leads extend to the surface and are carried to some convenient point where the indicating instruments are placed. These instruments are calibrated to show any deformation in the concrete due to loading.

The instrument will shortly be used in an investigation which is to be carried out by a special committee sponsored by the Engineering Foundation on a dam to be erected at Fresno, Calif.

Chlorination of Condenser Water

RECENTLY the Paterson Engineering Co., London, England, has introduced a new process for the chlorination of the cooling water used for condensers. It has been shown that the incrustation in the tubes was largely due to the presence of a micro-organism in the cooling water and that the deposit of practically all of the organic matter in the water was the result of this situation. The addition of one part of chlorine to three million of water has resulted in the reduction of the cost of cleaning the tubes by about one-half, as has been shown by systematic tests at the central station of the Borough of Hackney. This of course does not take into account the increased efficiency of the whole plant, which, it is said, has been quite noticeable.

Socketing Wire Rope for Hoisting and Hauling

FREE END OF ROPE IS ARRANGED TO FIT INTO TAPERED BORE OF SOCKET, THUS EQUALIZING PULL ON STRANDS AND PREVENTING WEAR. BY J. B. PETRIE

ENGINEERS who are not familiar with hauling methods used in mines may be interested in the following account of how mining men fasten wire rope in a socket, which in turn may be attached to a suitable hook or other fastening on a skip, car or any other load it is desired to hoist or haul. The same method may be used on elevator ropes and in many other ways for hauling and hoisting in the industrial plant and often in the central station. As will be evident from the discussion and illustrations, the object of socketing wire rope for haulage in this way is to equalize as far as possible the load on the various strands of the rope, to prevent it from untwisting and to eliminate a bight in the end of the rope which always causes trouble. The following discussion takes up the methods used by the writer, employing both the closed socket and the leaf type open socket.

For rope in any size up to 1¼ in. diameter, the writer would use a closed socket, made of best quality iron or drop forged steel, as shown in Fig. 2A. The length of the barrel should be about seven times the diameter of the rope

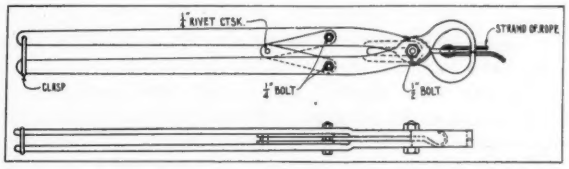


FIG. 1. TONGS FOR BENDING STRANDS OF ROPE WHEN PREPARING END FOR SOCKETING

and the loop end about the same length as the barrel. A slightly longer loop might be better, as it will allow the rope to pass through more freely. The bore of the small end of the barrel should be 1/16 in. larger in diameter than the rope and the large end of the barrel should be of a diameter that will give twice the area of the rope. The barrel should be machined inside or made on a good mandrel that will give an even taper. For bending strands of rope to attach this style of socket, the writer uses the tongs shown in Fig. 1.

To socket the 1¼-in. rope in the closed socket, proceed as follows:

First. Pass the rope end through the barrel of the socket as shown in Fig. 2B. From the free end of the rope, measure off twice the length of the barrel, as shown, and at this point serve good and tight with soft iron wire to hold the lay of the rope.

Second. Open up the strands and cut out the hemp core as close to the serving as possible. Leave two strands full length and cut the other four back from the end ½ in., 1 in., 1½ in. and 2 in., respectively. Tie all strand ends with strong twine as shown by dotted lines in Fig. 2B.

Third. Catch each strand with the tongs at the point marked AB, which is about midway between the end and the serving, and turn each end inward. Treat each strand in this manner and tie each loop with small twine to keep in place. The finished end should now appear as in Fig. 2C.

Fourth. Pull this finished end back into the barrel, apply the load and the job is completed.

For ropes above 1¼ in. in diameter, let us take for an example a 1⅝-in. diameter flattened strand type rope. This rope is made up of six strands, with 14 large wires and 12 small ones and a core which in this type of rope is three-cornered. For this, the writer would use an open socket of the leaf type, machined to the correct taper both inside and outside, with three buckles machined on the inside to the same taper as the socket and of a bore that will allow them to drive to their proper position. Construction

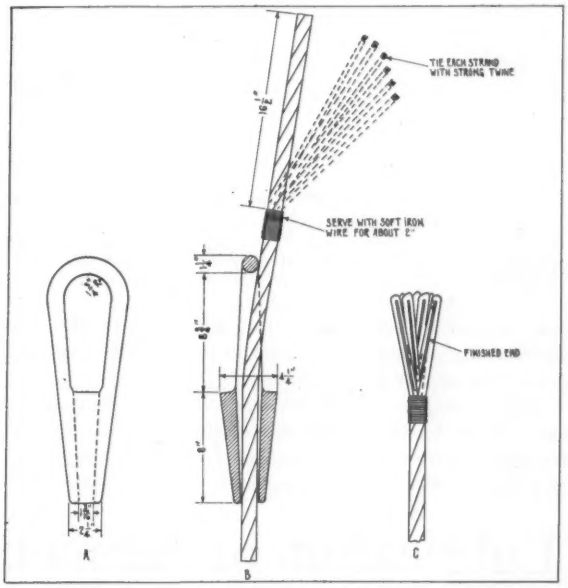


FIG. 2. DIAGRAM SHOWING OPERATIONS WITH CLOSED SOCKET

A—Closed socket is made of iron or drop forged steel, with bore of barrel tapered. B—Strands are cut to length, separated and served. C—Strands doubled inward produces tapered end to fit tightly into barrel.

of this socket is shown in Figs. 3D, 3E and 3F. The buckles are made with lugs on them, as shown, so that they can be driven onto the socket, and the lower one may be drilled for attaching safety chains to the cage or car.

To prepare the rope end for this socket, proceed as follows:

First. Measure off from the end 17½ in. and at this point serve with soft wire for about 3 in.

Second. Unlay all six strands separately. Straighten out all wires and cut them as follows, the lengths being measured from the serving: Cut four large wires 5 in. long, four large ones 7 in. long, the three-cornered wire and two small ones 9 in. long, two large ones 11 in. long, four small ones 13 in. long, one large and six small ones 15 in. long, and three large ones 17 in. long. The rope end should then appear as in Fig. 3A.

Third. At point X, turn back all wires, laying them against the rope and spacing them evenly, to give regular taper, as in Fig. 3B.

Fourth. Serve the rope end with strong iron wire as tight as possible and as many times as will be necessary to compress the turned wires solidly together and against the

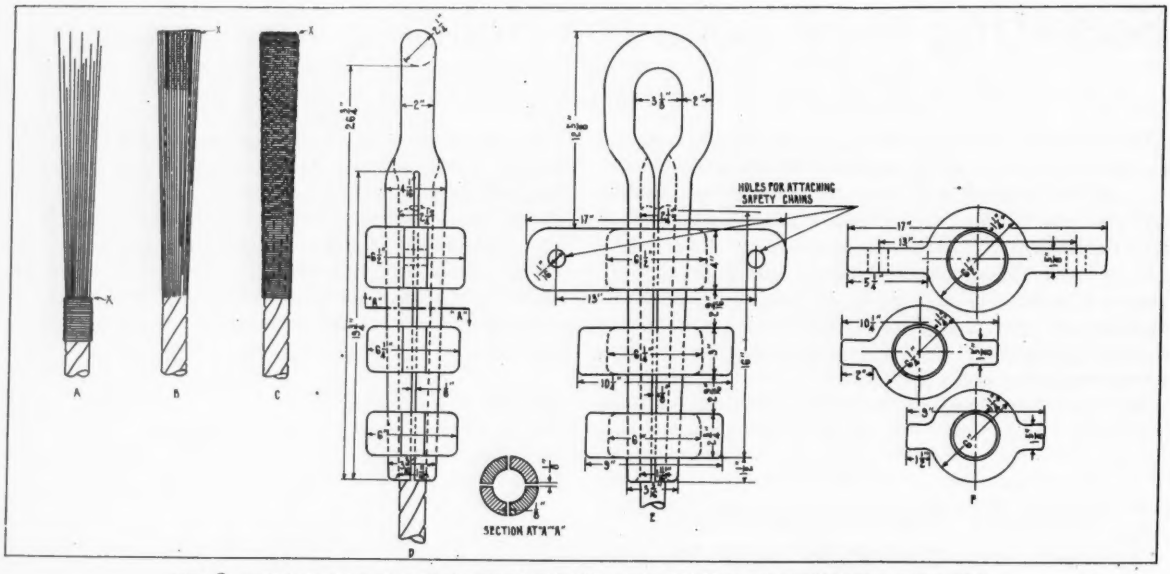


FIG. 3. DETAILS OF LEAF TYPE OPEN SOCKET AND METHOD OF PREPARING ROPE END

A—Strands are inlaid and wires are separated and cut as described above. B—Wires are turned back along rope at X to give taper. C—Taper is served with iron wire, finishing with spun yarn. D—Leaves of socket are opened, tapered end of rope put in and buckles hammered down until tight. E—Bore of socket is tapered for rope end and outside of barrel is tapered to fit buckles. F—Plan view of buckles.

rope, one serving coming off as the other is going on. The final serving should be good spun yarn. The rope end should now appear as in Fig. 3C.

Fifth. Slip the socket buckles in their order onto the rope. Heat the bow of the socket slightly so that it can be opened easily. Then fit it over the prepared rope end. Drop the buckles back on the socket and drive them into place until all is solid, as shown in Fig. 3D. This completes the job.

For any other sizes of rope or for ropes made up of numbers and styles of wires different from the above, the lengths to be cut will be different but with a little calculation these lengths and the sizes of socket can easily be determined.

Lubrication of Ammonia Compressor Cylinders

DISCUSSION OF LUBRICANTS AND LUBRICATING METHODS USED ON MODERN TYPES OF OPEN AND CLOSED AMMONIA COMPRESSORS. BY RUSSELL J. NADHERNY

REFRIGERATING ENGINEERS often take too lightly the problem of lubricating ammonia compressors, with the result that troubles occur which cannot be accounted for until the lubrication system and the lubricant used are investigated. The requirements of ammonia cylinders from the standpoint of lubrication are entirely different from the requirements of steam or internal combustion engines. The oil is not washed away as it is in steam cylinders, nor burned as it is in internal combustion engines, but remains in the cylinder a long time. In this respect there is a similarity between refrigeration machines and air compressors; refrigeration cycles, however, are closed and the oil is held in the system, whereas in air compressors a certain amount of oil is carried away by the compressed air. The quantity of oil required for good lubrication is small and care should be taken not to use more oil than is necessary.

The kind of oil to be used in ammonia compressor cylinders is governed largely by the operating pressures, temperatures and speeds, by the type of compressor, and by the method of applying the lubricant. In all cases, however, an oil in order to lubricate ammonia compressor cylinders properly must not react with the refrigerant under existing conditions of pressure and temperature; its cold test should be low enough to resist congealing at the lowest temperatures encountered in the system and it must maintain a film on the rubbing surfaces under all practical operating conditions.

For lubrication purposes, ammonia compressors may be divided into two groups: the open types, such as that shown in Fig. 1, in which separate oils are used for cylinder and bearing lubrication, and the enclosed types illustrated in Fig. 3, lubricated by oil from the crank case.

One method of lubricating ammonia compressors of the open type is by pressure or gravity feed through oil holes in the cylinder walls, located at mid-stroke. The pistons are usually designed to keep the oil holes covered through the length of their stroke, thus preventing the displacement of oil from the oil lines by the high-pressure ammonia gas. Oil holes exposed during a part of the compression stroke are provided with ball checks. The number of oil holes is governed mainly by the size of the cylinder. Another method of lubricating open types of compressors is that of admitting oil into the suction line, just ahead of the suction valves. The oil is finely atomized and carried by the flow of gas into the cylinder. All exposed surfaces, including the valves, are sprayed with oil. Many of these surfaces do not require lubrication and they merely accumulate oil, most of which is carried into the expansion coils by the ammonia gas, decreasing the heat transferring capacity of the coils. Oil that remains on the valve and cylinder surfaces not requiring lubrica-

tion is likely to gum unless it is of the highest quality. Gumming may cause sticking and improper seating of the valves, which affects the efficiency of the compressor, and eventually causes mechanical difficulties. The latter method of lubrication, even if functioning properly, is wasteful. Contrary to common belief, modern types of automatic valves require little, if any, lubrication.

Lubrication of the piston rod is of great importance and is affected largely by the construction of the stuffing-box, details of which are shown in Fig. 1 and Fig. 2. A gas vent should lead as shown from the packing between the cylinder and the oil gland to the suction line or to some point outside of the compressor room.

Enclosed types of compressors are ordinarily single-acting and the cylinders as well as the bearings are lubricated with the same oil. In the splash method of lubrication commonly employed, oil is distributed to the various moving parts by being thrown from the crank which dips into the oil held in the oil-tight crank case. With tight fitting piston rings, there is little danger of oil leaking past the pistons and finding its way into the expansion coils, where it would produce an insulating effect, thus reducing the efficiency of heat transfer. Some of the newest designs incorporate full pressure lubrication, as shown in Fig. 3.

Oils for the lubrication of ammonia compressor cylinders must be pure mineral oil containing no compounding, i. e., animal, vegetable, or fish oils. The fatty acids, which are almost invariably present in the latter, react with ammonia to form soaps. Soaps when mixed with mineral oil give greases, but greases are not suited for ammonia cylinder lubrication. They cause unnecessary drag on the piston and are likely to plug up the valves and other parts of the system. In the refining process, oils should be highly treated and filtered to remove from them the unstable and objectionable constituents which are chemically active and cause gumming. Oils should be neutral, as all acids react with the alkaline ammonia, forming salts. The flash point is not of great importance and need be only high enough to prevent losses from evaporation. Oil vapors will not burn in an atmosphere of ammonia gas, hence the dangers of explosions are negligible.

Cold test requirements of ammonia compressor oils are governed by the operating conditions. Where suction pressures are above 15 lb. per sq. in. ga. an oil with a pour point of 0 deg. F. will be satisfactory. For suction pressure lower than 15 lb. per sq. in. correspondingly lower cold tests are required. Where the suction pressure

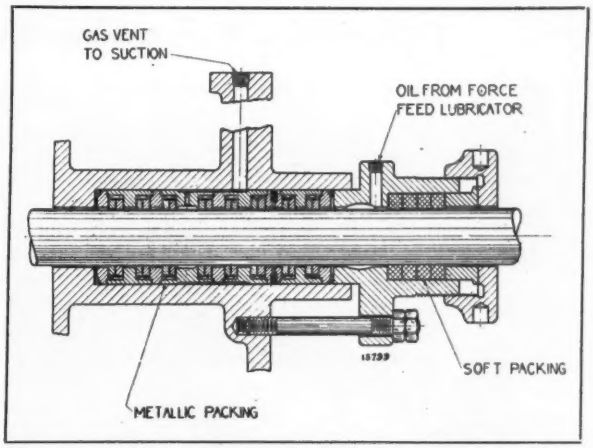


FIG. 2. DRY GAS VENT BETWEEN HIGH-PRESSURE AND LOW-PRESSURE PACKING RINGS IS PROVIDED IN STUFFING-BOX

is around 5 lb. per sq. in. ga., oil with a pour point of 15 deg. F. below zero is necessary. Lower cold tested oils are more desirable, though not essential.

As to viscosity, the oil should be heavy enough to maintain a film on the friction surfaces without causing unnecessary drag on the moving parts, with a resultant loss of power. For ammonia cylinder lubrication alone, an oil with a viscosity of 100 sec. Saybolt at 100 deg. F. is well suited. Higher viscosities may prove better for certain types of compressors. That, however, can be best determined by making various tests. Where bearings and cylinders are lubricated with the same oil, it should have a viscosity of 150 sec. Saybolt at 100 deg. F. or higher. The higher viscosity is necessary because of high bearing pressures.

On account of differences in construction of the various types of compressors, and the variation in operating conditions, it is not practical to make absolutely rigid rules for the lubrication of compressors in general, nor to specify any one grade of oil.

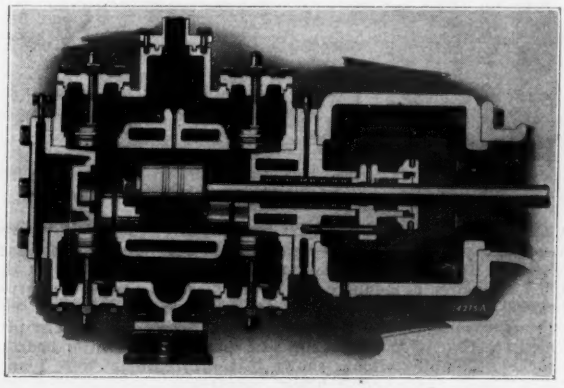


FIG. 1. FORCE FEED LUBRICATOR SUPPLIES CYLINDER AND STUFFING-BOX OF THIS OPEN TYPE COMPRESSOR

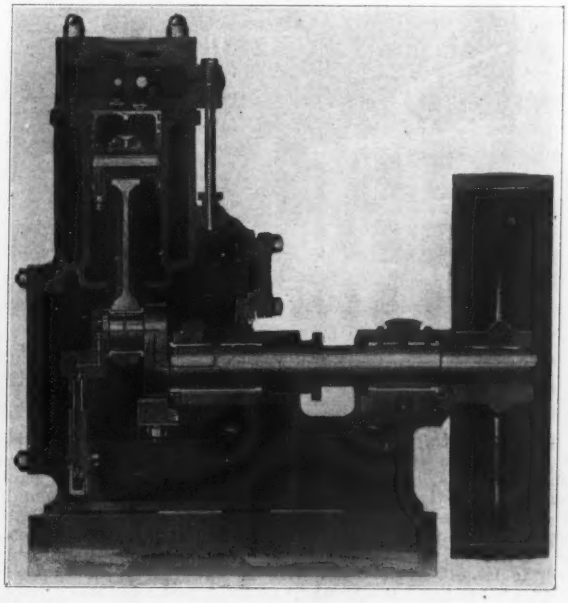
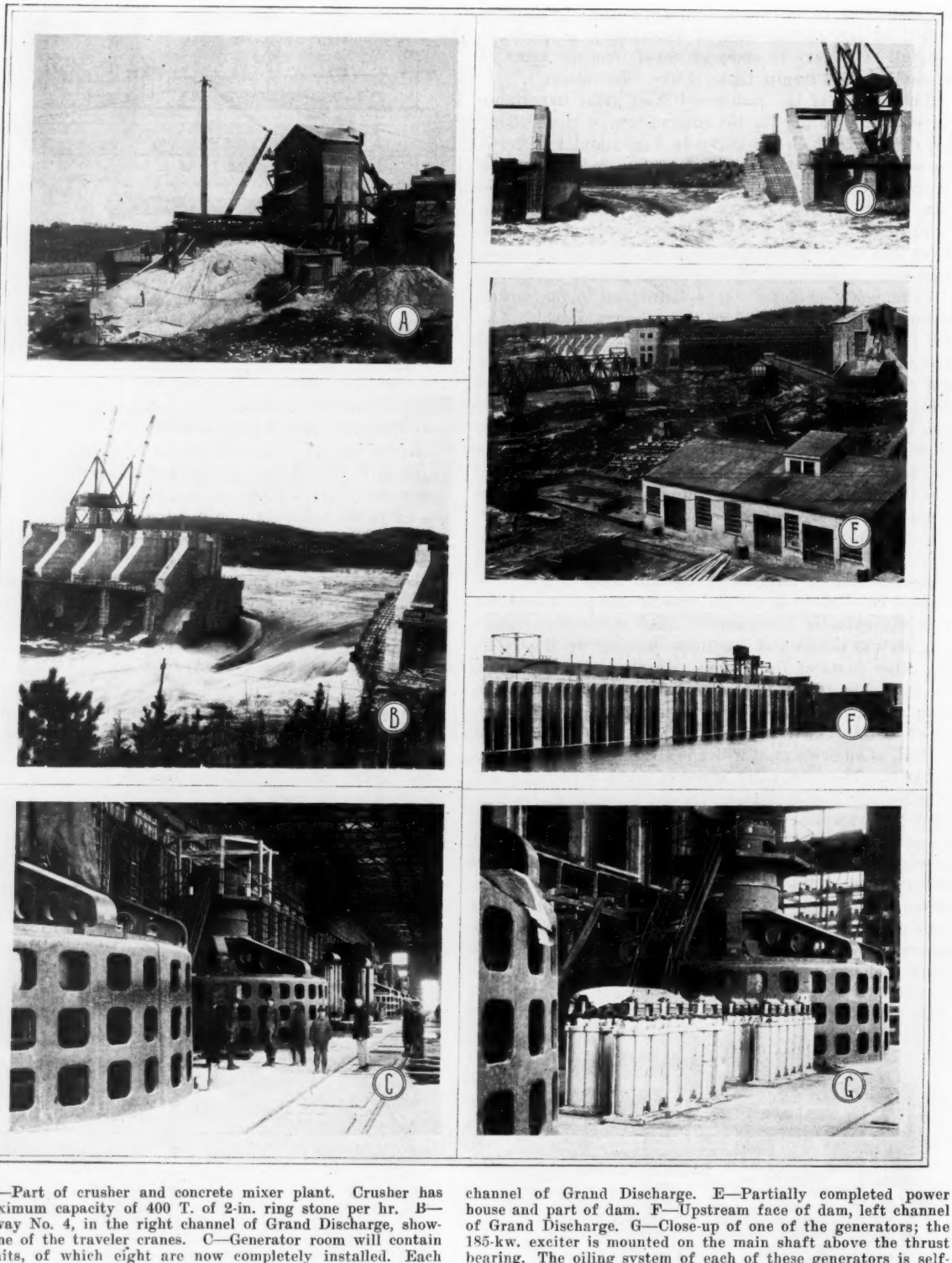


FIG. 3. THIS ENCLOSED FEATHER VALVE COMPRESSOR HAS FORCED LUBRICATION FROM OIL PUMP DRIVEN BY CRANK

Construction Work at Isle Malinge Plant on Saguenay River



A—Part of crusher and concrete mixer plant. Crusher has a maximum capacity of 400 T. of 2-in. ring stone per hr. B—Spillway No. 4, in the right channel of Grand Discharge, showing one of the traveler cranes. C—Generator room will contain 12 units, of which eight are now completely installed. Each generating unit will have a rating of 45,000 hp., making a total of 540,000 hp. When all units are installed this will probably be the largest single installation in water power development ever undertaken. D—Another view of Spillway No. 4, right channel of Grand Discharge. E—Partially completed power house and part of dam. F—Upstream face of dam, left channel of Grand Discharge. G—Close-up of one of the generators; the 185-kw. exciter is mounted on the main shaft above the thrust bearing. The oiling system of each of these generators is self-contained and automatic in operation. Large brakes are provided for four of the eight arms of the lower generator bearing bracket. The oil switches shown in the foreground were placed there merely during construction operations.

Saguenay River Furnishes 540,000 Hp.

ISLE MALIGNE HYDRO PLANT NEAR LAKE ST. JOHN, CONTAINING TWELVE 45,000-HP. UNITS, WILL BE COMPLETED IN JANUARY, 1926

AT ISLE MALIGNE on the Saguenay River, Province of Quebec, Canada, an installation of hydro-electric generating equipment, designed for an ultimate capacity of 540,000 hp. is now being made, reputed to be the largest single installation in water power development ever undertaken. Eight of the turbo-generators, each of 45,000-hp. rating, are at present in place and the remaining four are partially installed.

Isle Maligne is the last of a group of islands in the Grand Discharge, one of the branches of the Saguenay River, which leads from Lake St. John, about 100 mi. north of the city of Quebec. By grant of the Canadian Government, the Duke-Price Power Co., Ltd., which is constructing the Isle Maligne plant, is permitted to utilize the storage capacity of Lake St. John between ordinary low water and ordinary high water. This storage capacity is estimated at about 187.1 billion cu. ft.

In building this plant at Isle Maligne in a remote section with difficulties due to water and floods, careful planning was necessary. The design and layout of the construction plant were given as much attention as the design of the power house, according to a statement by W. S. Lee in a paper presented before the A. I. E. E. If this had not been done at Isle Maligne the large amount of work necessary could not have been done on scheduled time.

Construction work on this project was begun in December, 1922, and the entire plant is expected to be completed by January, 1926. The first step in the work was the construction of a railroad about 11 mi. long from Isle Maligne to Hebertville, where it connected with the Canadian National Railway line. This line, laid on ballasted road-bed with 70-lb. rails, crosses the Bedard River and the right channel of the Grand Discharge at the foot of Isle Maligne. All bridges are of steel on concrete piers; the longest, at Isle Maligne, has two spans of 90 ft. and one of 220 ft. This railroad was completed and transportation begun across the bridge to Isle Maligne at the end of October, 1923.

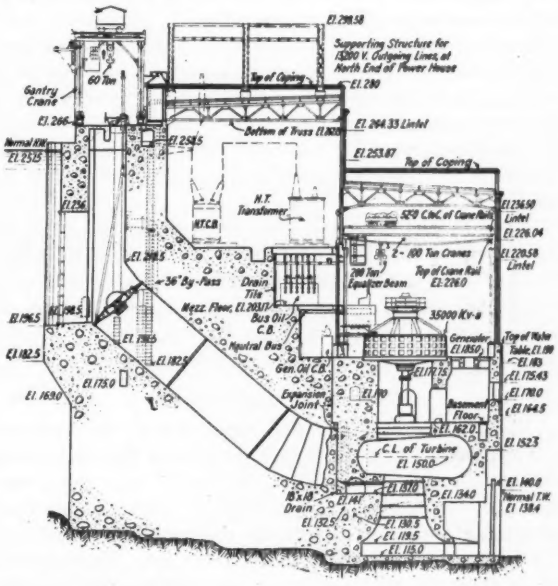
Work on the construction camp was begun as soon as the railroad was completed. Great care was exercised in the design and building of the construction camp, which housed and fed 1600 workmen, many of them with their families. The camp was made self contained, since the community is isolated, especially in winter, and has a store, bank, post office, hospital, school, a resident physician and other facilities making for sanitation and comfort.

CONSTRUCTION WORK WAS CAREFULLY SCHEDULED

Progress schedules were made out for the construction work on the project, the time for beginning and finishing some of the operations being determined by climate and stream flow. In the Grand Discharge, 502,000 cu. yd. of concrete masonry were called for and in the Little Discharge 20,000 cu. yd. For the tail race and foundation work 320,000 cu. yd. of material had to be excavated. A track system was laid out, connecting with the railroad terminal, and containing 15 mi. of track leading to all parts of the job, thus eliminating job haulage by any other means.

On the Alma shore near the double track bridge across the Grand Discharge, the crusher and mixer plant was located, within easy reach of a sand pit and quarry, supplementing the stone supply from the tail race excavation. The crusher and mixer were also centrally located with respect to the largest spillways. The machinery for this plant is all driven by 2200-v., 60-cycle, 3-phase, slip-ring motors.

Excavation work necessitated large quantities of compressed air. A portable 210-cu. ft. compressor, driven by an 8 by 8-in. gasoline engine and a 340-cu. ft stationary steam-driven compressor were used on the earlier cofferdam construction. The main compressor plant, on Alma Island, 300 ft. south of the Isle Maligne bridge, consists of two 25 by 15¾ by 18-in. compressors, each of 2033 cu. ft. capacity, driven by two 350-hp., 2200-v., 200-r.p.m., synchronous motors. Completely equipped machine shops and carpenter shops were installed, together with a saw mill, the latter having sawed 10,000,000 board feet of lumber up to the end of 1924.



SECTION THROUGH ISLE MALIGNE POWER HOUSE, SHOWING EXPANSION JOINT BETWEEN BULKHEAD AND SUBSTRUCTURE

Electric power for construction work was brought in over a 44,000-v., three-phase transmission line, 40 mi. long, from the Chicoutimi hydro plant of Price Bros. & Co., Ltd., which is connected with the Saguenay power development.

Concrete is delivered from the mixer plant in cars holding boxes of 4-cu. yd. or 2-cu. yd. capacity; these cars were run opposite the chutes and the concrete discharged direct to its final place in the forms. Five traveler cranes were installed for the construction of the power house bulkhead and for subsequent use on Spillway No. 4. Twenty-five hoisting engines of the double drum type are used on the various derricks, each one being driven by a 100-hp., 440-v., 900-r.p.m., a.c. motor. Each spillway, except No. 2 and the middle channel of Little Discharge, is equipped with Stoney type steel regulating gates.

In constructing the power house, provision for expansion was made as shown in Fig. 1, the massive bulkhead structure being separated from the cut-up substructure containing the turbines by a longitudinal expansion joint and by transverse joints spaced 108 ft. apart. The power house itself is 720 ft. long and 163.5 ft. wide. At the upstream face of the power-house bulkhead is a rack of concrete and reinforced steel. Each intake is 16 by 22 ft., and a rectangular butterfly valve is provided as shown in the section. This valve is actuated through a connecting rod raised and lowered by a 230-v., d.c. motor. Weather-proof push-button control is provided for each hoist on top of the bulkhead, with an emergency control at the power house bench board. Each turbine flume converges into a 22-ft. diameter opening to the steel intake pipe, which is connected to the turbine casing by a plate steel stuffing box.

Draft tubes are of hydro-cone construction. When all turbines are operating at 110-ft. head, the total discharge into the tail race will be 50,400 cu. ft. per sec., with a maximum velocity of 8.1 ft. per sec.

Twelve vertical-shaft, single-runner, Francis-type turbines, having plate-steel spiral casings and operating at a speed of 112.5 r.p.m. are installed. Eight turbine units are now completely installed and all the parts which go into the concrete for the four additional units are in place. The range in head on these turbines is between 100 ft. and 120 ft.

An individual governor system operating under an oil pressure up to 220 lb. per. sq. in. is provided for each turbine, and the piping is so arranged that the governors may be operated separately or as an interconnected system in units of four. The closing time for the governor for the full stroke of the servo-motors is three seconds.

Electrical Equipment

Eight generators, directly connected to the turbines now completely installed, have a continuous full load rating of 30,000 kv.a. or 24,000 kw., at 80 per cent power factor, 13,200 v., three phase, 60 cycles, 112.5 r.p.m. They are guaranteed for a temperature rise not to exceed 55 deg. C.; the required exciter capacity is 185 kw. Each generator is equipped with an upper and lower guide bearing. The thrust bearing on top of the generator is of the Kingsbury type and its housing is provided with water cooling coils.

Individual exciters, placed above the thrust bearings, have a full load rating of 185 kw. at 250 v. and 112.5 r.p.m. and are guaranteed for a temperature rise not to exceed 40 deg. C.

The oiling system of each generator unit is self contained and automatic in operation. Large brakes are provided for four of the eight arms of the lower generator bearing bracket.

The triple-pole, single-throw, oil circuit breakers are identical in construction and of the same capacity. The rating of each circuit breaker is 3000 amp. at 15,000 v. and the guaranteed interrupting capacity is 65,000 r.m.s. amp. at 13,200 v. Direct current at 230 v., for the operation of the mechanism, is furnished from a 25-kw. motor-generator set.

On an extension of the mezzanine floor into the generator room, between units No. 6 and 7, is the bench-board, of the continuous closed type, 40 ft. long. The auxiliary vertical board, containing recording ammeters, voltmeters, watthour meters and relays, is 16 ft. 4 in. long and 7 ft. 6 in. high. The control circuits are for 230 v. and the lighting circuits for 115 v.

For station use, there are installed two banks of transformers, located in the center of the high tension room; each bank consists of three 200-kv.a. single-phase transformers, stepping down the voltage from 13,200 to 550 v. Crane motors and the sixteen headgate hoist motors now installed, are using 230-v. direct current. The power for operating these motors is furnished by a 200-kw. motor-generator set. The three air compressors supplying compressed air for the governor system and the two air compressors for general station use are driven by alternating current motors at 220 v.; power is furnished through three 25-kv.a., single-phase, 550- to 220-v., step-down transformers. For station lighting the current is stepped down in three 25-kv.a., 550/110-v., single-phase transformers.

Proper Supply of Spare Parts Aids Plant Operation

Securing and maintaining in the power plant an adequate stock of extra parts or "spares" is a problem that merits thoughtful consideration. This applies to all sorts and types of apparatus, whether it be steam, gas, ammonia, electrical or other class of equipment. Whenever a piece of new equipment is installed in plant, steps should be taken at once to determine just what are the wearing portions of the apparatus, just what are the parts that are absolutely essential to the operation of the same, and then place an order for those parts. Care should be taken to determine the correct quantity of each part that should be carried in stock. Determining factors to be taken into consideration are availability of the parts from the manufacturer, length of time required for shipment of the same, probability of necessity of replacement due to breakage or wear, quality of material, soundness of castings.

Upon receipt of the spare parts a careful inspection should be made of them to determine their condition after shipment; check should be made to make sure that they are the proper parts ordered and that they apply to the particular apparatus for which they were ordered. In too many cases spare parts have been ordered promptly but upon receipt they have been left in the packing boxes unopened until the emergency arises at which time they are hurriedly opened and found to be unsuitable for the purpose intended.

After having been unpacked and inspected each part should be tagged with information showing order number, firm, name of part, number or serial of part, date of receipt, and name and number of machine to which the part belongs.

All spare parts should be kept in one place, properly protected from the action of the elements and from accidental abrasion or breakage. At the time each spare part is used steps should be taken to place an order for duplicate shipment of the same in order to keep up the stock.

Steel tanks used for the storage of water, fuel oil and other liquids should be emptied and thoroughly cleaned at least once every year. The accepted idea that this operation is not necessary in the case of fuel oil is erroneous and costly.

Worn Valve Discs Cause Sprinkler Troubles

RECENTLY, I inspected a sprinkler system which had been giving trouble, and found that the outside gong had rung at short intervals until it finally refused to ring at all; the electric alarm bell had followed the same tactics, the main line gathered moisture which continually dripped on finished and unfinished work, and a stream of water continually issued from the drip of the alarm valve. To cap the climax, at intervals this valve gave forth weird squeaks and groans which in the stillness of the night were not exactly soothing to the watchman's nerves.

This matter had been called to the attention of the company originally installing the system, but their work had been unsatisfactory and even after several attempts at repairing, the same troubles continued.

After an intensive study of the diagrams furnished by the company manufacturing the alarm and check valve, I felt that I was on the trail of the cause of all these difficulties. I took off the cover plate of the check valve and was delighted to find that my diagnosis was correct.

This valve is double ported and the disc not only covers the entrance to the system but the end of a pipe leading out through the wall of the valve to the mechanism actuating the various alarms. The fit between this pipe and the secondary disc fastened to the main disc, must be as tight as mechanical skill will permit. But there are difficulties attending repairing and refitting when a leak is found. With the facilities of the ordinary shop, it is practically impossible to grind the disc and pipe together, so the disc must be removed and ground on a face plate or other flat surface. If it protrudes ever so slightly from its former position when reinstalled, it will prevent the check valve from closing entirely, thus there will be a momentary flow whenever the pressure on the main is greater than that on the system, thus opening the port to the alarm valve and ringing the bells.

My first attempt was only partially successful in that I still maintained the metal-to-metal contact and, although I took great pains, I could not grind them with a degree of precision sufficient to make a tight fit. I made considerable improvement, however, the groans noticeably subsiding and the bells, which I had previously repaired, ringing only a few times a day.

But I was not satisfied. I felt that I could end the troubles permanently. It occurred to me that a piece of thin sheet packing would have the resilience necessary not only to make a tight joint but to permit sufficient movement for the disc to seat itself. Following out this idea I was delighted to find that my idea was satisfactory and now all troubles are ended.

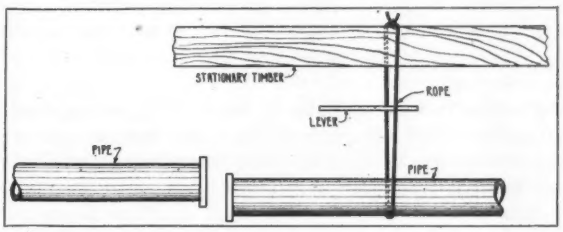
Some time in the future this bit of packing may wear through, but it will be the work of only a few moments to put in another piece and it may wear indefinitely, as there is little action except when the drip is opened for inspection and when the pressure on the mains becomes greater than that already on the system.

This rarely happens, for the pressure on sprinklers is that due to the maximum of some previous surge in the mains. The outside gong furnished a lot of work but no difficulties. The boss on the gong was worn down so that the striker barely touched it. The pin holding the impeller to the shaft was gone so that it merely turned, doing no work. Scale had lodged in the nozzle delivering water to the wheel and almost entirely closed the screen. The electric alarm needed new batteries and readjustment. Precipitation of moisture on the pipes ceased when the flow of water through them stopped, for with no movement, the water in them soon reached room temperature.

Keene, N. H. ARTHUR H. PARKER.

Spanish Windlass Gives Great Pull in Small Space

ALTHOUGH the so-called Spanish windlass has been in use for generations, even yet there are mechanics and power plant operators who do not realize that this simple



IRON BAR USED AS LEVER TO TWIST ROPE PROVIDES MECHANICAL ADVANTAGE IN LIFTING OR MOVING HEAVY WEIGHTS

improvised tackle is one of the most useful "kinks" in the power plant. I have seen men who were considered first class mechanics, held up on a job for the lack of a turnbuckle, screw-jack, pulley blocks, or a crowbar, when the use of this elementary appliance would have overcome the trouble.

This device is made by a loop of ordinary rope as shown in the accompanying sketch. The loop is placed over the two pipes, a short lever is placed in the center of the loop and twisted. This shortens the length of the loop and the pipe will be raised to the desired height.

The power that can be applied by using a short length of iron bar or a strong strip of wood is enormous, limited only by the strength of the rope used.

It may be used in location where space is restricted, hence the reason for its frequent use on ships.

Toronto, Canada. JAMES E. NOBLE.

Piston Ring Joints

RECENTLY at a small machine shop I overheard a conversation between the machinist and the customer about the placing of piston rings on the piston of a gasoline engine. The customer said he had broken several in trying to put them on, whereupon the machinist picked up a ring, holding it at points A, Fig. 1, and proceeded as shown in Fig. 2, the joint being put on first. The ring was then gradually opened and shoved down over the balance of the piston, thus expanding the ring gradually and evenly, the whole operation taking but a few seconds.

On this subject of piston rings the writer has found that where the joint is cut as in Fig. 3, with fillets in the angles and the corners rounded as at B and C, it makes a good, leak proof joint. The fillet stiffens the tip of the

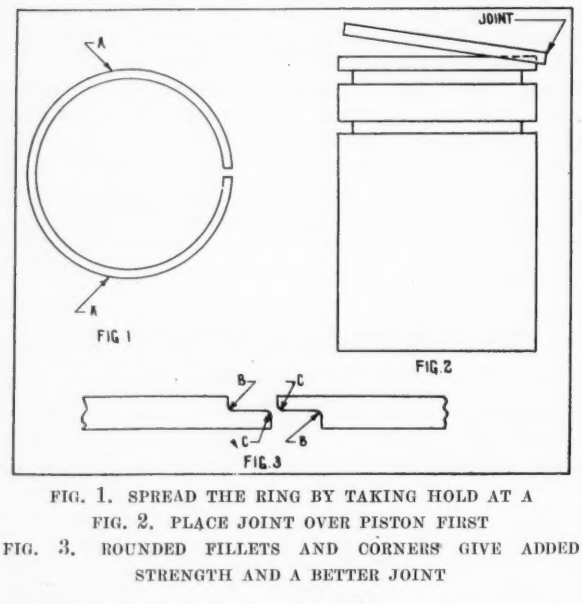


FIG. 1. SPREAD THE RING BY TAKING HOLD AT A
FIG. 2. PLACE JOINT OVER PISTON FIRST
FIG. 3. ROUNDED FILLETS AND CORNERS GIVE ADDED STRENGTH AND A BETTER JOINT

ring so that it is not as liable to break as if the angles and corners were left square, and the steam leakage past the ring will be less than if the joint is made with the ordinary straight bevel.

Texas. TOM JONES.

Opportunities Outside the Power Plant for Operating Engineers

RECENTLY there has been much discussion about the tendency of many operating engineers or chief engineers to complain that they had reached the end of the string in their plants. Mr. Thorn, writing in the August 15 issue, tells of such a case, where Bill Smith was sure that the only thing that would save the day was more equipment. Jim Jones, replacing Smith, found, however, that by taking advantage of the opportunities offered, he was able to make the equipment already installed do the work easily.

Dozens of cases of this kind may be found. On the other hand, there are many engineers who really have their own houses in order, and are looking for more worlds to conquer. They are getting the best results that can be obtained with the equipment at hand and have taken advantage of every chance to make improvements in the power plant.

Such men are often capable of making studies in the plant, outside of the power plant, that will lead to suggestions for the most economical uses of process steam, current and various other appliances. This is a direction in which many chief engineers could work and show big savings.

Not so many years ago, if a chief were to go to his superior, the plant superintendent or the general manager and suggest that a certain process could use exhaust steam instead of live, thereby effecting a considerable saving of money, he would have been told, "You trot on back to your power plant and pay attention to your own business. Your job here is to keep the supply of steam and current going as it is called for; and when you put the steam into the pipes and the juice on the wires, that's enough! You don't need to worry about how they are being used."

But such a day is past. The operating engineer or chief should have an opportunity to carry his knowledge and training out into the plant where his steam and current are being used and to suggest (even if his suggestions aren't always carried out) changes that would save money for his company.

We read of the mills where enormous quantities of live steam are being used in process work, such as textile and paper mills, while exhaust steam is being wasted to the atmosphere; or where condensing turbines are furnishing power that could be better furnished by non-condensing units supplying medium-pressure process steam; or even where power is purchased and process steam supplied from the boilers through pressure-reducing valves, when the power could be obtained for next to nothing by the use of the proper generating units.

Even in the plants that use only small quantities of heat in process work, the engineer will nearly always find here and there live steam being used for heating a vat or a tub, where exhaust steam, fed through a larger pipe, would do the job quite as well, or he will find places where electric heat has been installed on the theory that "it's out-of-date if it isn't electric," without regard to whether it might be the logical method of heating or not. Probably at the same time, exhaust steam has been blowing out through an exhaust head for 90 per cent of the year.

All these are examples of glaring waste, not only waste of economic resources but waste of the firm's good money and a needless sacrifice of profits. The man who can show the company how to increase sales by $100,000 will be increasing the profits by only $15,000, or maybe $20,000; but the man who can show the boss how to eliminate $100,000 of wasted expenditures has pointed the way to increased profits equal to that entire amount. "A dollar saved is a dollar added to the profits."

This is where the engineer can often take himself out of the operating class and put himself in a rank with the executives. Of course, he will often meet with opposition from the managers or foremen of the plant departments in which he suggests the changes. The foreman of the dyeing room, for instance, may state that he has tried exhaust steam and that it won't work. Here is where an engineer has a chance to show both tact and ingenuity. One engineer, despairing of selling his idea to an obstinate foreman, put in a larger pipe to carry a sufficient volume of exhaust steam, and then fixed a gage so that it would show 75 lb. pressure with exhaust steam. The dyehouse, after using low-pressure steam for a week without any difficulty, woke up to the fact, but it was too late

then to protest that exhaust steam couldn't be used for dyeing.

Of course, such tricks as that aren't to be recommended, but the possibilities for saving money in similar cases are great enough to make it worth the engineer's while to use every legitimate means to put his idea across with the foreman concerned and with his boss.

For the engineer who feels that there is nothing constructive ahead, I should suggest a tour around the plant looking for such opportunities as these to make simple changes that will show attractive savings.

North Glenside, Pa. W. J. RISLEY, JR.

Encourage the Ideas of Your Subordinates

MANY engineers, even though having long experience with power plant problems, often get the wrong view of matters pertaining to power generation and make the mistake of considering a certain problem of no significance, merely because they have never studied particular phases of the subject. In one plant the main power supply was furnished by a 1250-kw. condensing turbine with a water rate estimated at 20 lb. per kw-hr. There was also an elevator pump of the direct acting type, using steam at 140 lb. pressure and exhausting into an open feed water heater, raising the feed temperature from 90 deg. to 200 deg. F. No other exhaust steam being available except from feed pump and fan, the feed temperature was seldom higher than 130 deg. F. when this pump was not running. A motor driven, triplex plunger type of pump was used for the regular elevator service and the steam pump used as a spare. The latter was never used except when the electric driven unit was down for repairs.

One day a rather lengthy shutdown for repairs was necessary and the steam pump was started. It was noted that the flowmeter on the boilers showed an increased flow of about 1000 lb. of steam per hour when the steam pump was running since its water rate was about 60 lb. per hp-hr., while current for the motor driven pump was generated by the main turbine with 23 lb. per kw-hr. or about 15 lb. per hp-hr. The chief engineer urged the repairman to get the triplex pump back into service as soon as possible since he considered the cost of running the steam pump excessive.

Now let's see if it really did cost more than the electric unit. About 20 hp-hr. were required for the triplex pump and an additional 300 lb. steam per hour had to be supplied to the turbine to run this pump. The boiler load increasing by 1000 lb. per hr. when the steam pump was started meant that it took 1000 lb. more steam to operate than the other unit or 4300 lb. per hr. in all. But this pump exhausted into the feed heater and all the exhaust was condensed by the feed water. Producing 20 hp. with 1300 lb. of steam showed a water rate of 65 lb. per hp-hr. Since 2546 B.t.u. is the heat equivalent of a horsepower-hour, the heat depletion per pound of steam was only 39 B.t.u. Now, since all the exhaust containing about 1154 B.t.u. per lb. (1193 — 39) was returned to the boiler in the feed water, only 5.44 per cent of the steam flow to this pump may be charged against the operation of the pump. So the actual steam consumption was: 5.44×1300 or 70.72 lb. per hr., which was equivalent to generating a horsepower hr. on 3.536 lb. of steam per hr. With coal at $7.50 per ton and a boiler evaporation of 8 lb. of water per pound of coal, operating 24 hr. a day, 300 days a year, the difference in operating costs may be shown as follows:

$$\frac{(300 - 70.72) \times 300 \times 24 \times 7.50}{8 \times 2000} = 773.82$$

This shows that it actually cost $773.82 more per year to operate the electric unit than the steam pump.

In another plant there was found a condition which likewise revealed the ignorance of the engineer. Two ammonia compressors of 15-T. capacity each were operated day and night during the summer months for the purpose of supplying chilled water at 35 deg. F. for a manufacturing process. They were driven by two 35-hp. motors run at full load under the conditions of operation. The engineer in charge insisted that the suction pressure should not exceed 10 lb., while the condenser pressure was held at 180 lb. If it dropped, he throttled the condensing water valve till it again reached 180 lb. His idea was that with 180 lb. on the high pressure side of the system, more ammonia would expand in the coils.

A new watch engineer coming into the plant wished to increase the water supply to the condenser, reduce the pressure to 150 lb. and have the suction pressure increased to 35 lb. which he said would reduce the power required to run the compressor. But the chief insisted that the ammonia had to be compressed to 180 lb. for the best results. He said: "The ammonia gets more chance to expand from 180 lb. to 10 lb. than it does between 150 lb. and 35 lb., therefore, we save ammonia by this method."

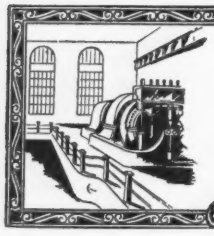
But after the chief left the plant in the evening, the new man having the night shift decided to operate according to his own ideas. After ascertaining that water temperatures below 35 deg. F. were not necessary, he decided that 35 lb. pressure in the expansion coils was not too high, since it gave a temperature in the coil of 22 deg. F. With the compressor taking gas at 35 lb. pressure, the capacity of one machine was as great as the two machines when operating at 10 lb. suction pressure and the condenser pressure was reduced to 145 lb. by increasing the water supply. He regulated the expansion valve so that the suction line was frosted all the way back to the valve, whereas the chief had always kept the suction line free from frost, which resulted in a return of superheated gas.

Since the power consumption was reduced in proportion to the reduction of head pressure and increase in suction pressure the current required to operate the refrigerating plant was reduced by more than half. The amount of gas that a cylinder takes per stroke is proportional to the absolute pressure, so that after increasing the suction head from 25 to 50 lb. (10 to 35 gage) the capacity was doubled and the efficiency increased by reducing the clearance losses and supplying the compressor with gas at saturated temperature instead of allowing it to superheat.

Springfield, Mass. A. F. SHEEHAN.

THE REASON that the theatrical section of Broadway, New York, is known as "The Great White Way" is the number of electric signs which line it. Investigation shows that these signs use 1,095,841 electric lamp bulbs, and a special crew of 50 men makes the rounds of these signs nightly to replace burned-out lamps.—N. E. L. A. Bulletin.

DON'T EXPECT a steam line to stay tight unless the joints have been made properly and adequate provision has been made for expansion and draining.



QUESTIONS AND ANSWERS

Condenser Vacuum Falls Off Under Load

WE HAVE, connected to our turbine, a barometric condenser which has a 5⅜-in. neck at the bottom of the cone and an 18-in. exhaust pipe connecting the turbine to the condenser. With 74-deg. inlet water and the turbine and piping cut off entirely from the condenser, we can get a 28-in. vacuum but, as soon as we connect the turbine and the piping to the condenser, vacuum will drop to about 20 in., then slowly come up to about 26 in. When we start the turbine, the vacuum does not change and, running up to a load of 300 kw. on a 375-kv.a. generator, the vacuum still stays at that point. The temperature of the water in the hot well reaches 92 deg., showing an increase from 74 to 92 deg. at a load of 300 kw.

We have had two engineers from the turbine company look over our turbine and have had it overhauled completely, so feel quite sure that it is all right. We also had a representative of the condenser people here and he felt that, as long as the condenser pulled a vacuum of 28 in. which, as soon as the turbine was started, fell to 26 in., it was due to air leaks. The turbine cover, however, was taken off, both the inlet and exhaust pipes filled with water and they showed no signs of leakage. The cover was put on and sealed up with powdered graphite.

The condenser is rated at 1360 g.p.m. The generator is rated at 375 kv.a., 80 per cent power factor, or 300 kw., and the water rate of the turbine at that load is between 39 and 40 lb. of steam per kw-hr. Assuming 40 lb., it would make a total of 12,000 lb. of steam per hr. passing through the condenser and dividing that by 60 will give us 200 lb. of steam per min. The ratio of water to steam on the condenser is figured at 55 and multiplying the 200 lb. by this figure gives us 11,000 lb. of water to take care of this steam. Dividing that by 8.3 gives a capacity of 1325 g.p.m.

The best vacuum that we are able to get on cold water with the turbine shut off entirely is 28¼ in., with the inlet water valve on the condenser closed, 13 turns out of a total of 16 required to close the valve entirely. When we are running our turbine, however, we have to increase the water, due to the fact that it would heat up and thus reduce our vacuum. Why can't we get a higher vacuum?

M. H. M.

Boiler Repair Questions

EXAMINATION questions given to applicants for positions as stationary engineers in Massachusetts are often difficult and I wish to submit a few to readers for their answers. I am particularly anxious for information on boiler repair work, as I have been unable to find any books on this subject. The questions are as follows:

1. How would you straighten out a corrugated bag in a boiler extending about halfway on each side of the first and second sheets? The dimensions of the bag are approximately 53 in. by 33 in. The job may be done without taking the water from the boiler and the inspector will allow 100 lb. steam pressure.

2. This same boiler has three lugs along each side. Which lug carries the most weight?

3. If the length of the boiler is 15 ft. 11 in. over all, and it is desired to install new tubes, what is the proper length to cut them?

4. Which is the quickest way to put in a new top head in a vertical tube boiler of 48-in. diameter?

5. If you were starting to retube three or four vertical tube boilers with about 300 tubes each and a repair gang was taking them all out, where would you start to put them in? How would you hold them in place?

6. How would you test the check valve in the main return line of a gravity heating system? A. R. C.

Indicator Cards Show Power Distribution

AS SUGGESTED by Messrs. Mason and Cultra, a discussion regarding the cards published on page 713 of the July 1 issue would be of more interest and value to readers if the low pressure cards had been printed. Accordingly, I am sending a set of cards, together with a short description of the engine from which they were taken. This is a horizontal cross compound duplex blowing engine, size 25/52 by 54/54 by 48 in., fitted with automatic air valves, Corliss valves in the low and piston valves in the high pressure steam cylinders, both sides with double eccentrics. The air pressure is normally 15 lb.; steam pressure, 150 lb.; 100 deg. superheat and a vacuum of about 22.4 in. of mercury, which is about 4 in. absolute at this altitude.

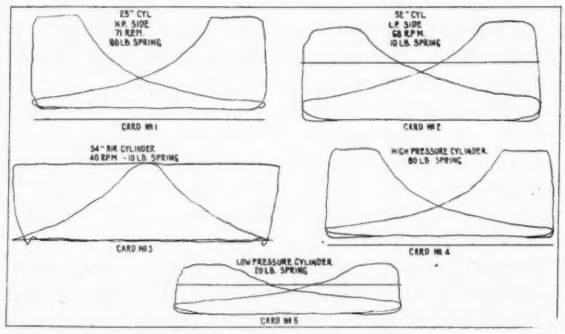


FIG. 1. LOW AND HIGH PRESSURE STEAM CYLINDER CARDS. ALSO AIR CYLINDER CARD

As shown in Fig. 1, Card 1 is from the 25-in. high pressure cylinder; Card 2 from the 52-in. low pressure cylinder, and Card 3 from the 54-in. air cylinders, both of which give exactly the same card. Unfortunately, the

cards were not taken at the same time and as conditions vary greatly, the indicated horsepower will not check. Under normal conditions the low and high pressure sides balance at about 6½-lb. pressure. The low pressure cutoff is controlled by hand so that the operator may vary it with the load or discharge pressure, which varies from 12 to 17 lb. Cards 4 and 5 are included as a matter of interest and show the valve setting as left by the manufacturer's erecting engineer.

Release is late on all cards, but the matter of lead and compression is open to discussion. The air cylinder is in tandem with the steam cylinder and should give sufficient cushioning to insure smooth running, regardless of compression in the steam cylinder. If we take the high pressure side, neglect the mechanical efficiency of the engine and assume Cards 1 and 3 typical, they will show, when superimposed, the result illustrated in Fig. 2. The pressures from Card 3 have been multiplied by the cylinder ratio $(54/25)^2 = 4.66$, in order to make it comparable with Card 1. From this it is evident that during the first part of the stroke the steam cylinder furnishes more power than the air cylinder requires. This excess goes either to the low pressure side, which is 90 deg. ahead, or is stored in the flywheel. At about 42 per cent stroke, the steam cylinder is just carrying the air cylinder, while past this

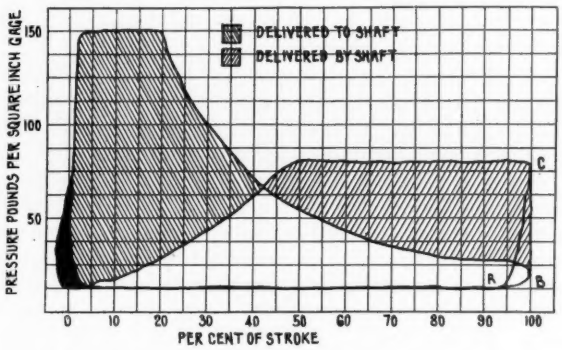


FIG. 2. POWER DISTRIBUTION FROM HIGH PRESSURE CYLINDER

point the power deficiency must be made up from the low pressure side of the flywheel. With cards taken simultaneously and the steam cylinders balanced, the steam expansion and air compression lines will cross at about midstroke and the two cross hatched areas will be about equal. The small black area at the head end of Fig. 2 represents the work done by the air in expanding from the clearance volume of the previous stroke. This helps the steam cylinder and represents useful work.

During the first part of the stroke, the steam cylinder is delivering power to the flywheel and the condition shown by position I in Fig. 3 results. Somewhere about midstroke this condition is reversed and the flywheel begins pulling the piston as shown by II. This continues to the end of the stroke. If steam were not admitted to the crank end at this point, the piston would be reversed due to the expansion of air trapped in the clearance space. This movement of the piston in the reverse direction would continue until the crank end expansion line intersects the head end compression line at point A, Fig. 2, close to the atmospheric line, and at about 5 per cent of the stroke. Therefore, regardless of admission, the crank would pass dead center without shock or jerk to the condition illustrated by III, since the change in position of the crankpin, from one side of the box to the other, is a rolling motion while the crank passes dead center. If admission occurred before 5 per cent stroke, the condition in III would continue until midstroke, but if delayed beyond 5 per cent the conditions would be reversed, as shown by IV, while the flywheel was carrying the load, but would assume the original condition of III shortly after admission.

Friction and momentum will reduce the limit of 5 per cent stroke considerably and in this engine the steam valves set without lead are designed to give full pressure in the cylinder at from 2 to 3 per cent of the stroke. The engine runs smoothly without knocking at any speed and it was not thought advisable to stop the engine to slip

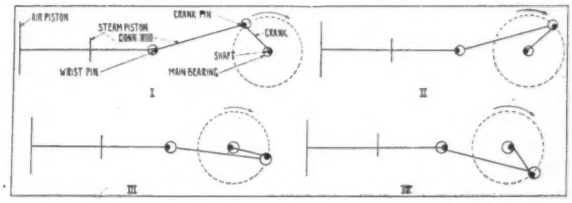


FIG. 3. EFFECT OF ANGULARITY OF CONNECTING ROD

the exhaust eccentric ahead until the engine had to be stopped for some other purpose, which may be a matter of two or three months.

I am much interested in the matter of lead on engines of this kind as it is a subject which is always open to discussion.

Clarksdale, Ariz. RICHARD H. MORRIS.

Counterbore Prevents Shoulder Forming

WHAT IS meant by the "counterbore" in the cylinder of an engine? J. H. C.

A. Steam engine cylinders are counterbored for the purpose of preventing the formation of a shoulder in the cylinder wall. Were it not for the counterbore, into which the piston partly projects at the end of each stroke, the piston would not wear the cylinder walls their entire length and shoulders would be formed at each end of the cylinder. When the wear of the joints in the connecting-rod is taken up, the length of the connecting-rod is slightly decreased, and the piston is moved slightly towards the crank end of the cylinder. In this case the shoulder would cause an undesirable pounding of the piston.

Barometric Condenser Tail Pipe Length

IN A SIPHON or barometric condenser, why is it necessary to have the hot well 34 ft. below the condenser head? A. A. W.

A. In a siphon or barometric condenser, the hot well should be 34 ft. below the condenser so as to overcome the atmospheric pressure and thereby prevent the drawing of water into the engine cylinder. Theoretically, the pressure of the atmosphere is equal to the pressure exerted by a column of water 34 ft. in height. A perfect vacuum is never reached but it is well to allow a distance of 34 ft. in order to be safe.

EDITORIAL COMMENT

Preheaters Have Earned Consideration

Modern boiler practice has reached the point where further improvement is an effort to secure part of the proverbial last 10 per cent efficiency. Boiler tests have, on several occasions, resulted in efficiencies greater than 90 per cent and in a number of plants the daily results of operation exceed 85 per cent over all boiler efficiency. Yet we are not satisfied. We want every heat unit in the coal we buy delivered into the steam which leaves the boiler.

To get even a part of that last 10 per cent may, for a time, cost more than it is worth, nevertheless, if progress is to be made, the pioneers must pay the price of the experimental work. If successful, nearly every improvement can be put on a commercial basis and thus reduced in cost, making it a profitable investment for plants that cannot afford to experiment.

This has been the experience with feed-water heaters, economizers, superheaters, stokers and nearly every other piece of equipment conceived and developed to increase plant economy. Now comes the air preheater as a means of preventing losses heretofore unavoidable, preventing furnace wall deterioration and improving combustion.

Several types of air preheaters are now in use, as pointed out on other pages of this issue, and have proved highly successful in a number of installations so that the experimental engineering stage has been passed and the problem now remaining is that of making them more universally profitable to install.

Engineers can aid in this direction by giving more consideration to the preheater in their plant designs and plans for improvements. Its field of usefulness has not yet been clearly defined and, whether the engineer should rule for or against the preheater, becomes a distinct problem for each plant. General improvement in the field is the outgrowth of individual successes.

All in the Day's Work

Maintaining service under all conditions is the aim of every electric public utility company. The industry has educated the public to expect uninterrupted power and, as engineers all know, the average non-technical power user has little conception of the complication of men and material necessary to satisfy his demands. If service is interrupted by an accident, he seldom thinks of the long hours of overtime, the resourcefulness and ingenuity of executives and workmen in devising temporary expedients, the struggle with the elements, all forming a great epic of service.

So, when a bolt of lightning wrecked the switch house of the Superior hydro plant of the Detroit Edison Co. not long ago, another opportunity was given for a demonstration of the efficiency and sound engineering judgment of an organization that had been carefully trained to meet emergencies. The story of how service was restored in a brief period and how a temporary, eight-position, wood-pole, switching station was constructed in 26 hr., and on a holiday at that, is told elsewhere in this issue. Working in the night by the faint light of lanterns and truck headlights, staggering with fatigue, cheerfully giving up their cherished holiday, these workmen showed that they recognized to the full the company's obligation.

Naturally, the people of the surrounding country that the system serves considered the accident an unusually serious one, although the company officials were not unduly disturbed. The spirit of co-operation shown by the residents of the affected district was a splendid tribute to the understanding that this great company has built up between itself and its customers.

Then, too, in looking back over the progress of the work, no one is able to say that if certain things had been done instead of those that were done, the final result could have been attained quicker and better. This is an interesting comment on the resourcefulness of the men in direct charge of the work.

It must not be imagined that the men who performed this feat considered that they were doing anything to win unusual attention. It was all part of the day's work with them. Similar situations arise in many cases that are never heard of outside the organization that handles them. Our reason for making mention of this particular one is that it serves as a typical example of what the employes of a great public utility are expected to do in an emergency, without fuss or feathers, to maintain the service that the public has been educated to expect from the company. An occurrence of this kind once in a while, inconvenient though it is for everyone, yet serves to show the public the stuff of which a successful public utility organization must be made.

Power Plants Should Help in Smoke Abatement

In a recent statement the Fuels Division of the A. S. M. E. points out the need of closer harmony between all users of fuel, both commercial and domestic, if smoke abatement is to become effective.

The American Society of Mechanical Engineers, the American Society of Heating and Ventilating Engineers, the Stoker Manufacturers Association and the American Civic Society are now co-operating in this work and one of the results of their efforts is the proposed Standard Smoke Ordnance published in the May, 1924, issue of Mechanical Engineering by the A. S. M. E. Reprints of this ordinance may be obtained through the secretary of this society.

Foreign fuel consumers are even more interested than we in America. The British Smoke Abatement Society estimates the actual loss suffered in London through smoke at a million pounds per day. One of their statements, particularly worthy of note, is as follows : "Even on fogless

days we allow sunlight of infinite value to be intercepted by the pall of smoke which overhangs our great towns. The climax of absurdity is reached when we have to organize special sunlight treatment, in some cases with rays artificially generated, in order to cure diseases caused by this unnatural darkness. The classic instance of Pittsburgh proves that the evil can be remedied once a community is really alive to its seriousness."

Glance up at your own stack! Are you polluting the atmosphere and jeopardizing the health and happiness of the community?

Can a Coal Strike Be Justified?

Recent wage study of the anthracite mining industry conducted by the National Industrial Conference Board, brings out some highly illuminating facts. This research covered 140 mines, representing about 90 per cent of the commercial production of anthracite and employing 92,000 wage earners, or 65 per cent of the total number employed in the anthracite field.

With 1914 as the basic 100, wages in the building industry are now 211, in manufacturing, 229, in railroads, 241, and in anthracite mining, 292. In June, 1914, contract miners averaged $3.46 for a 9-hr. day. They now average $9.11 for a 7½-hr. day. Their real earnings, that is, wages expressed in terms of purchasing power, are today 176 per cent of 1914 value, as against 145 per cent real earnings for manufacturing industries.

1920 was the peak year for every industry except coal mining. During the buyers' strike of 1920, every other wage earner endured a slump but practically no revision was made in the anthracite mining industry and today wages in that field stand nearly 32 per cent higher than in 1920.

What of the Future of Power Plants?

Prophecy is at best liable to go wrong because of unforeseen developments which throw even predictions based on a most careful analysis of past history and present conditions out of line.

After noting power plant progress for the last 15 years, and especially the great strides in combustion methods, size of units and transmission effectiveness in the last five years, one might conclude either that we were approaching the limit in progress or that we are just getting started toward greater advances.

It is interesting, therefore, to consider the conclusions reached by one who has made so careful a study of the subject that he was awarded a substantial prize by a committee of the ablest men in the industry as having produced the best prophecy out of a large number presented.

David Cowan of Montreal is the youngster who bested all competitors and who, by the way, is in the investment department of a life insurance company but has made a specialty of economics. He writes as of the year 1930, hence is predicting the progress of the next five years from 1925.

Size of units, he thinks, will not have greatly increased, but stations will have grown to 600,000 kw. Steam pressures will have advanced so that 600 to 1000 lb. will be frequent, but higher pressures will be barred by the limit of safe temperatures for metals. Coal will still be the leader among fuels but 1 lb. of coal per kw.-hr. will be common. Powdered fuel will have become predominant for large plants using low-grade bituminous and anthracite coal and lignites, but the mechanical stoker will hold its own for good-grade bituminous, anthracite and coke breeze.

While plants of less than 500 hp. will have largely disappeared, many factories needing 500 hp. or more will still find it economical to make their own power, particularly where steam is needed for process work. Steam making by electric boilers will be used, even up to large capacities, where water power is abundant and surplus power is available during off-peak periods.

Hydraulic development will have increased from the 8,093,000 kv.a. of 1925 to 11,500,000 kv.a. by 1930, but the largest units will not be much over 70,000 hp. Many stations and of large size will be remotely controlled, making available power development distant from the systems which they feed.

Long distance transmission voltages will have increased but little, but systems will be fully interconnected in each section of the country, one in the north east, one in the south east, one in the central west and one for the Pacific coast and Rocky Mountain section. This will have been made possible in part by working agreements but more by combination of many operating companies into one organization through the formation of holding companies.

Other predictions are made as to growth of the output, number of customers, capital invested, methods of financing and the questions of rates and public relations but they are not of immediate interest at this point.

Showing the variation which may arise in deductions made from like data, analysis of the six papers leading in the contest shows a range of predictions, in some matters rather wide, in others agreeing remarkably well: For energy generated in 1929, from 90,000,000 kw-hr. to 72,000,000; for gross revenue, from $3,080,000 to $1,939,380,000; for capital invested, from $12,000,000,000 to $9,450,000,000; for rated generating capacity, Jan. 1, 1930, from 41,000,000 kw. to 23,200,000 kw.; for capacity of largest plant, from 823,500 kv.a. to 600,000 kv.a.; for largest steam units, from 100,000 kw. to 50,000 kw.; for largest hydraulic units, from 75,000 hp. to 70,000 hp.

The most extreme operation conditions foretold by any of the six papers are: coal per kw-hr., 1 lb.; steam pressure, 1500 lb.; mercury boiler and turbine in wide use; transmission voltage, 380,000; farm use of electricity grown to be one of the best loads.

Certainly, in all this there is no wild-eyed enthusiasm which has overborne sane judgment. At the present time, steam units of 60,000 kv.a. are in use and 80,000 kv.a. on order; several plants of 750,000 kv.a. are already planned and completion expected before 1930; hydraulic units of 70,000 hp. are now delivering current; energy output for 1924 was practically 60,000,000,000 kw-hr.; capital invested in 1925, $6,600,000,000 with nearly $580,000,000 increase during the year.

This growth, as discussed, is for central stations only and, as has been previously pointed out by Power Plant Engineering, there has been no slowing up in growth of individual plants during the last 10 yr., but growth of the central stations has been much more rapid than that of isolated plants due to increase of demand for current for domestic use and for small industries.

Viewed from any angle, the outlook for the future of the power plant industry seems most promising and electricity is utilizing steam,—not displacing it.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Unit Pulverizer Constructed with Five Stages

UNIT PULVERIZERS developed recently by the Grindle Fuel Equipment Co., a subsidiary of the Whiting Corp., are so designed that tramp iron and other foreign substances are removed from the coal which is then pulverized to a fineness suitable for furnace firing.

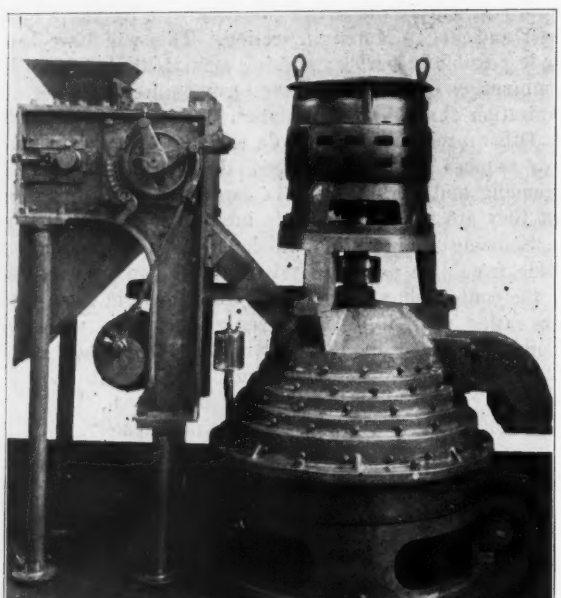


FIG. 1. FEEDER MECHANISM IS BELT-DRIVEN FROM THE PULVERIZER MOTOR

The feeder consists of a cast-iron housing, supported independently from the pulverizer but operated through a worm and gear by means of a belt from the pulverizer shaft.

Coal is chuted to an endless belt in the feeder. This belt travels over a magnetic pulley, thus removing tramp iron and depositing it in a box, which is readily accessible for cleaning. The coal passes over the magnetic pulley and through a chute from the feeder to the first of five stages in the pulverizer, which is of the vertical-shaft type. The rate of coal feed is regulated by means of a cam and ratchet device which changes the speed of the endless belt. The bee-hive housing of the pulverizer is made of cast iron and the rotor is made of cast steel. Cast steel beater holders are pivoted to the steel-plate discs and are free to swing 90 deg. to either side. The beaters are manganese-steel castings which slip onto the beater holders. Pulverizing rings, which are bolted to the bee-hive housing, are corrugated and made of high carbon, open-hearth steel. Below the pulverizing zone are fan blades for blowing the coal from the pulverizer. The entire rotor, including discs, beaters and fan blades, is fastened to a steel shaft, which is direct connected through a flexible coupling to an 1800-r.p.m., vertical-type motor. Gravity lubrication is obtained by means of a sight feed oil cup, which furnishes oil to the top bearing, the oil then dropping to the lower and thrust bearings. Placed opposite the top disc, to catch foreign material such as iron

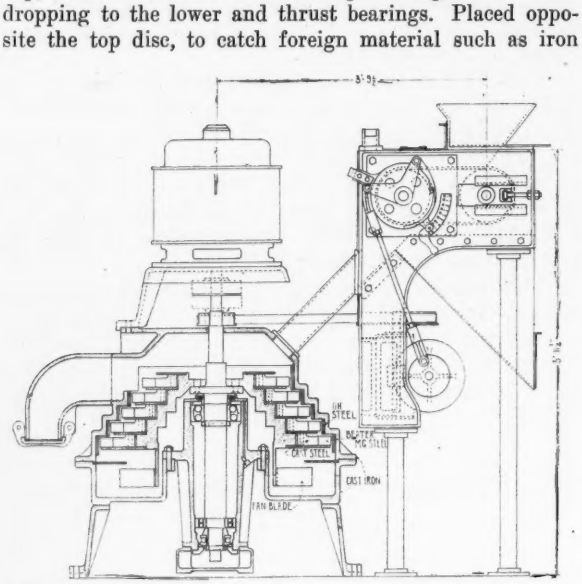


FIG. 2. COAL FALLS TO THE FIRST OF FIVE STAGES

pyrites, stones, wood and brass, is a cast-iron pocket. A vertical hand hole, 6 in. wide by 15 in. long, in the bee-hive housing gives ready access to the beaters for replacement. A complete set of beaters can be replaced in from 15 to 20 min.

Operation of the pulverizer is as follows: The coal slides down the chute from the feeder and falls on the top disc of the pulverizer and is immediately thrown out against the corrugated pulverizing rings. On the rebound, the beaters strike it, pulverizing it fine enough to pass down to the next stage and so on until it reaches the discharge chamber. The clearance between beaters and rings is such as to give proper pulverizing action and yet eliminate wear on the pulverizing parts when the machine runs empty.

The pulverizer itself furnishes air at high pressures and low volumes, making it possible to blow the coal through small diameter pipes to the furnace, where additional air for combustion can be supplied. The pulverizer can be equipped with an exhauster fan wheel of sufficient capacity to furnish all the air necessary for combustion. In most cases a separate supply of combustion air is deemed more practical.

New Recording Pyrometer

MANY features are incorporated in the new recording pyrometer recently developed by The Brown Instrument Co. This new recorder has a die cast black enameled aluminum case. It is built to make a single record, a duplex record with two records side by side, or in multiple form to produce as many as 12 records on one chart.

It operates on the principle in which a pointer swings freely and, at intervals of every 30 sec., is depressed on a carbon or inked ribbon producing a mark on the chart.

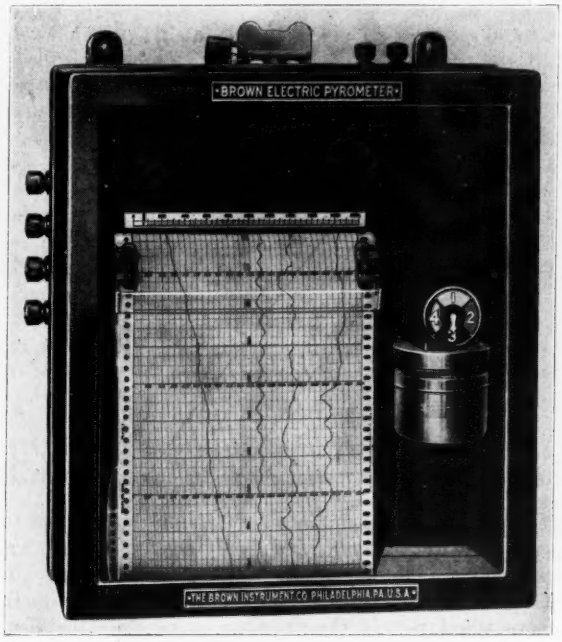


FIG. 1. NEW BROWN RECORDING PYROMETER WILL MAKE AS MANY AS 12 RECORDS ON ONE CHART

These marks are so close together as to form a continuous line. The marking ribbon and chart last two months before renewal is required and no inking is necessary. The marking ribbon is above the paper so that the mark is produced on the front side of the paper where it shows clearly. The ribbon in the single and duplex recorder is moved back after each mark on the chart, disclosing the last impression so that the record is clearly visible immediately after it is produced. A platen is supplied on which notes can be recorded on the chart with pen or pencil. A glass knife edge is also furnished for tearing off the paper, being located directly below the driving roll. The paper can be torn off 2 hr. after the last impression is made. For example, a complete record for the previous 24 hr. and ending 6:00 a. m. can be torn off about 8:00 a. m.

Galvanometer and the recording chart mechanisms are carried on a hinged frame. When swung aside, the galvanometer is readily accessible. In addition to recording the temperature on the chart, an indicating scale is provided with large figures legible at a considerable distance. The chart has rectangular co-ordinates. The time lines are straight across the chart. The recorder is driven by an electric clock if alternating current is available. Six recorders consume only the current required by an ordinary 25-watt incandescent lamp. Where alternating current is not available a hand-wound clock can be supplied.

Chart speed can readily be changed and is supplied for a number of combinations. The standard chart speed is 1 in. per hr. but by reversing two gears a speed of 4 in. per hr. is obtainable. Speed combinations are available from ¼ in. per hr. to 6 in. per hr. With a standard chart speed of 1 in. per hr. about 12 hr. of chart is visible through the front of the case. A reroll attachment is furnished

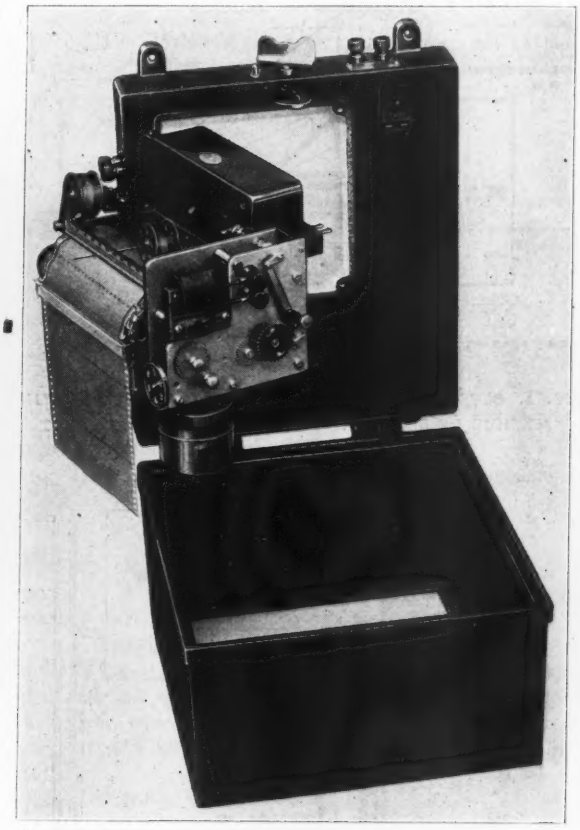


FIG. 2. RECORDER OPENED TO SHOW ASSEMBLY

where desired to roll up the chart automatically over a long period of time.

As a multiple recorder, this instrument incorporates an automatic switch with gold contacts mounted on bakelite and immersed in oil which prevents tarnishing of the contacts from corrosive gases in the atmosphere. The multiple recorder switch includes a dial with index for indicating the number of the thermocouple or furnace which is being recorded at the time. The record lines are made in different color combinations on the chart and the switch dial is numbered and colored to correspond.

NEW ENGLAND POWER CO., with headquarters in Worcester, Mass., has started work on a second dam across the Deerfield River, 5 mi. south of the big Whitingham dam. The new dam will be much smaller than the Whitingham dam and will be located near the State line at Monroe Bridge, Mass. It will have a fall of 78 ft. to an automatic power house where the electrical development will be 9000 kw. The plant at Whitingham generates 45,000 kw. The reservoir of the new dam will set the water back the entire 5 mi. to the tail race of the present Whitingham development. As in the case of the Whitingham dam, the new dam will be of earth construction.

Recording Smoke Detector

INSTANTANEOUS indication and a graphic record of the density and duration of all smoke produced by the boiler to which it is attached, is the claim made by The Engineering Corp., Long Beach, Calif., for its new Kingsbury recording smoke detector. The complete instrument

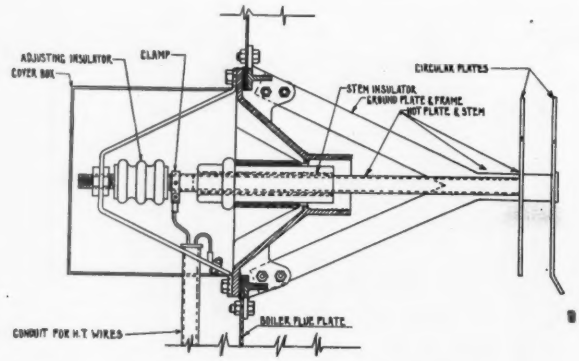


FIG. 1. SECTION OF SMOKE DETECTOR ELEMENT, SHOWING METHOD OF SUPPORTING AND INSULATING ELEMENT

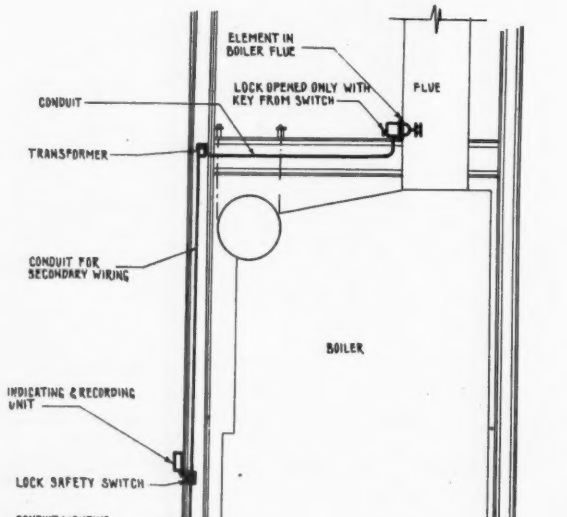


FIG. 2. ELEMENT IS CONNECTED TO PRIMARY AND RECORDING DEVICE TO SECONDARY OF TRANSFORMER

consists of an element inserted in the boiler flue, a transformer, a lock switch, and an indicating and recording unit of the switchboard type. The element shown in Fig. 1 consists of two plates placed in the primary circuit of the transformer and mounted so that the flue gas will pass between them.

Conductance between the plates of the element increases as the density of the smoke passing between them and causes a flow of charging current in the secondary circuit of the transformer, which is indicated and recorded instantaneously by the indicating and recording unit. Figure 2 shows the method of installing the device.

Application has been filed for patents covering the principle and design of the Kingsbury recording smoke detector.

Soot Blower Element Withstands Temp. of 2000 Degrees

CONSTRUCTION of the Marion Machine, Foundry & Supply Co.'s type "EB" soot blower is such that the blowing element passes through a wall box which is stationary in the furnace wall and is fastened to the rotating members with set screws. In operation, the revolving parts rotate around a stationary brass tube, screwed into

CAST-IRON YOKE IS SECURELY FASTENED TO THE GOOSENECK

the gooseneck. A cast-iron yoke, securely fastened to the gooseneck with set screws and firmly anchored to the wall box, holds the blowing head and prevents it from working loose from steam thrust. Stops and an indicator on the sheave wheel permit the operator to regulate the blowing arc, preventing steam jets from striking against the baffles and furnace walls.

Elements for the hot passes are made of Marion Hi-temperature Special alloy and resist oxidation up to 220 deg. F. The elements are fitted with internal welded nozzles, venturi type, so spaced that the steam jets strike directly between the tubes of the top row. The nozzles, being welded inside the elements, do not catch on bearings, should it be necessary at any time to remove them from the boiler setting. Being welded, they become integral with the element and will not become loose from oxidation. The element is revolved by a sprocket chain. This soot blower is equipped with Valve-in-head. The valve and valve seat are located in the top flange of the gooseneck. A lever, situated on the riser pipe in convenient reach of engineer, operates the valve. When ready to blow, a downward pull of the lever releases steam, cleaning the tubes and driving the soot and fine ash up the stack or into the combustion chamber. An upward thrust of the lever immediately closes the valve.

ORNAMENTAL wrought iron flower baskets have been placed on the poles carrying the "white way" street lights at Camden, Me., through the work of Mr. and Mrs. Edward W. Bok, summer residents of Camden. These baskets are filled with flowering plants and hanging vines similar to the ordinary house basket and the Garden Club of Camden, of which Miss Teresa F. Arau is president, details members of the club each week to see that the flowers are watered.

Robert W. Larkin of National Engineer Is Dead

ROBERT W. LARKIN, for twenty-five years manager of the "National Engineer," died at his home in Chicago on August 15, 1925. While Mr. Larkin had been in ill health for some time and had suffered three strokes, his death came as a shock to his many friends and associates.

He was born in Dublin, Ireland in 1865 and upon coming to America in 1887 established himself at once with the Chicago Title and Trust Co. in Chicago. Some two years later he undertook the publication of the "National Engineer." His unusual ability and forceful character was soon recognized by the National Association of Stationary Engineers and during his long association with the society earned an enviable reputation for sincerity and integrity. Besides his connection with the N. A. S. E. he was a member of numerous political and religious organizations. He is survived by a widow, two daughters and three sons.

Coal Distillation for Lakeside, 1200 Lb. for Green Bay

EXTENSIVE expansion programs have been laid out by the Milwaukee Electric Railway & Light Co., Milwaukee, Wis., which is controlled by the North American Co., according to a recent announcement. An agreement has recently been signed by the North American Co. by which the International Combustion Engineering Co. of New York will install its equipment for low-temperature distillation of coal at the Lakeside plant of the company at Milwaukee.

This will be the first installation of this method of low-temperature distillation system in America, it is stated. It has been perfected after more than two years of experimentation at the Lakeside power plant by John Anderson, chief engineer of the Milwaukee company and engineers of the International Combustion Engineering Co. The initial plant to be installed at Lakeside will provide for the treatment of at least 210 T. of coal a day, which is about one-fifth of the plant's present coal requirements. The coal is pulverized before being heat-treated and the oils, gas and other residuals are recovered under low temperature. This leaves the coke in such form that it can readily be burned in a pulverized-fuel furnace. In fact, it is claimed that it can be burned with certain advantages over the burning of pulverized raw coal.

The Milwaukee Electric Railway & Light Co. is also planning the construction of a generating station near Green Bay, Wis., at a cost of $2,000,000, which will use pulverized fuel combustion equipment and a steam pressure of 1200 lb. It is proposed to connect the Lakeside station, the new Green Bay station, and the hydro-electric plants of the Peninsular Power Co. near Iron Mountain, Michigan, by a 250-mi., 132,000-v. steel-tower transmission line.

At the plant of the Wisconsin Traction, Light, Heat & Power Co., another subsidiary of the North American Co., at Appleton, Wis., changes and improvements are being made according to the designs of John Anderson, to enable the plant to burn pulverized fuel. It is not planned, however to utilize exceedingly high pressures here, as the steam conditions are determined by other factors.

Regulator Valve to Avoid Seat Cutting

IN THE Boylston pressure regulator, a new type of valve disc and seat have been used, so designed as to throw any cutting from flow of steam, while the valve

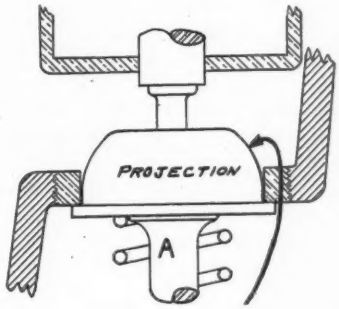


FIG. 1. VALVE DISC DESIGNED TO AVOID WIREDRAWING ON THE SEAT

is partly closed, to the body of the disc and away from the seat. Figure 1 shows the construction, the seat and bearing part of the disc being flat. The projection on top of the disc makes the area between this projection and the inside of the seat ring less than that between the disc and the seat so that wiredrawing takes place after the steam, which flows up through the valve, has passed the seat and wear takes place on the sides of the projection.

FIG. 2. IN 5 YRS'. USE, CUTTING TOOK PLACE AS SHOWN

Shape of the disc also throws the flow of steam away from the seat as it enters the throat, thus relieving the seat of wear. Pulsating and chattering are avoided for the flow through the throat is governed by the shape of the projection on the disc, not by the opening between the disc and seat, so that a dash pot is found unnecessary.

Figure 2, taken from a regulator in constant use for 5 yr., shows how the wear actually takes place. It was taken from a No. 205 pilot pressure regulator made by the Boylston Steam Specialty Co.

Fourth National Power Show

FROM November 30 through December 5 will be held at the Grand Central Palace, New York, the fourth annual exhibit of the National Exposition of Power and Mechanical Engineering. This differs from exhibitions devoted to a single industry in that power is a fundamental factor in every industry and a showing of machinery for economical generation and use gives opportunity for every industrial executive to discover some means of cutting his cost of production.

At the coming show a series of exhibits of heating and ventilating equipment will be an important feature in recognition of the increased importance that manufacturers attach to the need of good heating and ventilation for the factory. Advances in the art of power production are closely allied with those in heating, and improvements in method are usually applicable to both fields. Power plant executives will, therefore, find much of interest in the new section.

The list of exhibitors to whom space has already been assigned indicates the thoroughness with which the field of power generation will be covered. From handling of coal to the use of power at the shaft or motor, from the coal shovel to the elaborate equipment for conveying and storage, from the belt fastener to the leviathan prime mover, every class of apparatus that concerns power production will be represented.

Growth of the Power Show during the three years that it has been held is a good indication of the appreciation of American industry of its dependence upon cheap power for decreasing costs so that it may meet world competition. At the first show, 48,000 were in attendance, while last year the number was 79,000. In 1922, there were 100 exhibits on the floor, but at the third show, in 1924, 360 exhibits nearly filled three floors. For the coming show, 400 exhibitors have already signed contracts, proving that manufacturers of power equipment fully appreciate the value of the show as a clearing house for the latest news in modern developments.

Annual meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers will be held in New York during the week of the show and their programs will allow plenty of time for thorough inspection of the exhibits.

Managers of the show are Fred W. Payne and Charles F. Roth, with offices in the Grand Central Palace.

Standby Steam Station at Winnipeg

RECENTLY the new steam-driven electric generating station at Winnipeg, which serves as a standby plant to the City of Winnipeg hydro-electric system, was officially inaugurated. This station has three boilers fired with pulverized coal installed by the Combustion Engineering Corp., Limited, and two electrically heated boilers installed by the Canadian General Electric Co., Ltd. The turbine room contains two units of 5000 kw. each and one of 1000-kw. rating, all running at a speed of 3600 r.p.m. and manufactured at the James Howden & Co.'s Works, Glasgow. These turbines are coupled to Parson alternators and are supplied with steam at a pressure of 220 lb. per sq. in. gage and at a superheat of 150 deg. F. The 5000-kw. turbines exhaust into condensers which maintain a vacuum of 28 in. Hg. The 1000-kw. unit exhausts into the hotwell at a pressure of 1 lb. per sq. in. gage.

Official steam consumption tests were run on May 12, 1925, by the technical staff of the city hydro system under the supervision of Professor N. M. Hall of Manitoba University, who acted as independent referee. A summary of the test results is as follows:

Nominal load, kw	4905
Pressure in header, lb. per in. gage	227
Temperature of steam, deg. F	548
Vacuum recorded, in. Hg	27.27
Barometer recorded, in. Hg	29.47
Vacuum corrected to 30 in	27.80
Exhaust pressure, lb. per sq. in. gage	1.08
Duration of run-minutes and seconds	30'14"
Generator output, kw-hr	2470
Power factor, per cent	96.5
Condensate recorded, lb	30,962
Condensate, net lb	30,837
Water rate observed, lb. per kw-hr	12.48
Water rate corrected for pressure, temperature and vacuum, lb. per kw.-hr	12.11

The 5000-kw. turbines each have six stages with a mean blade speed of 760 ft. per sec. and the 1000-kw. turbine has four stages with a mean blade speed of 750 ft. per sec. A unique feature of these units is the totally enclosed governing and oil system giving a clean, neat and well finished appearance to the turbine at the high pressure end. Each day all three turbines are run up to speed to ensure that everything is in order and once a week they are put on the line. The 1000-kw. unit can be put on load within 3 min. and the 5000-kw. units within 30 min. The boilers supply the central steam heating system of the city, and thus if a sudden call comes for the standby plant to come on to the line sufficient steam is always available.

News Notes

DIAMOND POWER SPECIALTY CO. of Detroit announces that C. E. Aldrich will be located in Cincinnati as service engineer for that district.

HAYNES STELLITE CO. has just completed concentration of its activities at its plant at Kokomo, Ind. Administration, sales and engineering will be under the direction of C. G. Chisholm, General Manager.

F. F. GORHAM, for many years chief engineer of P. B. Yates Mfg. Co. at Beloit, Wis. (now Yates Beloit Corp.) has retired from active work and is succeeded as chief in the power plant by Herman W. Schultz.

RILEY STOKER CORP. has recently appointed two new agents to handle its various types of stokers. The states of Oregon and Washington will be cared for by the Heating & Ventilating Equipment Co., Seattle, Wash., and Southern Texas will be cared for by The Tennant Co., Houston, Texas.

ROLLER-SMITH CO. of New York has appointed the Tennessee Engineering & Sales Co., Knoxville, Tenn., as agents for the part of Tennessee and Kentucky within the Knoxville territory. Personnel of the Tennessee Co. is J. C. Buchanan who, since his graduation from the Bliss Electric School in 1924, has been connected with the meter department of the Knoxville Light and Power Co.; W. L. Tadlock, with the General Electric Co. at Ball

Lake since graduating from Carnegie Institute of Technology in 1924; S. E. Adcock, for several years with C. M. McClung & Co., and with Acme Electric Co. of Knoxville.

THE LINDE AIR PRODUCTS Co., New York, announces that its district sales office at Seattle is now located at 421 Railway Exchange Building, 619 Second Avenue, Seattle, Washington, with O. H. Davenport as district sales manager.

THE PITTSBURGH VALVE FOUNDRY AND CONSTRUCTION Co. announces the appointment of A. G. Hill, with offices at 45 Jarvis St., Toronto, Canada, as its agent for the Eastern Canadian district.

VICTOR MFG. & GASKET Co. is completing a 6-story addition to its plant at 5750 West Roosevelt Road, Chicago, at a cost of $1,000,000 and will move its fiber treating works from Rochester, N. Y., into the new building.

REGIONAL MEETING of the A. S. M. E. will be held at Altoona, Pa., Oct. 5 to 7. The morning technical sessions will be devoted to railroad problems and afternoons and evenings to inspection trips and entertainment. On Monday evening, honorary membership will be conferred by President William F. Durand on General William W. Atterbury, vice-president of the Pennsylvania system.

BELOIT BOX BOARD Co., Beloit, Wis., is now setting the foundation for a new 300-hp. Corliss engine, direct-connected to a generator, all to be furnished by Allis-Chalmers Mfg. Co. This extension was designed by J. A. Fisher, president of the Beloit Box Board Co., and when installed will be in charge of Geo. Schumacher, chief engineer.

AT THE new Kearney station of the Public Service Co., of New Jersey, temperature measuring equipment is now being delivered for what is believed will be the largest installation of its kind in America. This apparatus, furnished by Charles Engelhard, Inc., of New York, consists of 60 of their type S recorders calibrated for electric resistance thermometers to give a continuous record of 120 temperature points. These include feed water heaters, superheated steam, condensers, and other apparatus. The installation will involve 6 instrument panels, on which will be mounted 10 recorders.

WITH ECONOMY the national keynote at Washington it is natural that industries of the country should fall in line with the national trend. It has become a "brass tack" era, and will probably be so regarded by future historians. Bridgeport Brass Co., of Bridgeport, Conn., is doing its part to foster the "brass tack" idea by distributing free for convention purposes a neat little pin to those associations whose members use products similar to the brass goods made in the Company's factory. To others, because of the large demand for these little emblems, a nominal charge to cover costs has been found necessary. Bridgeport Brass Co. assures us that requests from readers of Power Plant Engineering will receive special consideration in the distribution of these emblems.

ON HIS 70th birthday, John R. Freeman, widely known hydraulic engineer, was given the degree of Doctor-Engineer by the Technical High School of Dresden, Germany, in recognition of his noteworthy activity in stimulating research in problems of hydraulics.

ANNOUNCEMENT COMES from Stone and Webster, Inc., who are the executive managers of the Columbus Co., that a contract to purchase the Georgia-Alabama Co. and the South Georgia Public Service Co. by the Columbus Electric and Power Co. of Georgia has just been signed. The new properties serve a number of communities in southwestern Georgia having a population of approximately 50,000, with electric light and power and also supply gas to one town and ice service to another. The total electric generating capacity is approximately 11,000 kw.

AMERICAN ENGINEERING COUNCIL, which is now in the fifth year of its activity, is to take up jointly with the Department of Commerce an exhaustive economic study of air transportation, which is intended to point the way to successful development of this industry in the United States. A study is also being made, through a competent committee, of the Reclamation situation, which is known to be precarious and committees on City Planning and Street and Highway Safety are working to encourage local engineering groups to take active part in the development of their respective communities, and in safeguarding life and limb for their fellow men.

SAMUEL INSULL has been elected president of the organization for the National Museum of Engineering and Industry which it is proposed to establish in connection with the Smithsonian Institute. Mr. Insull is aggressively pushing the organization; the campaign for members is in charge of a committee representing the national engineering societies and it is desired that the membership be increased so that dues received will take care of expenses of the early work in connection with the museum. Sustaining members pay $100, contributing members $75, affiliate members $25 and members $10 a year. H. F. J. Porter, 29 West 39th St., N. Y., is secretary of the membership committee.

PEJEPSCOT PAPER Co., which has extensive paper mills in Maine and owns valuable water power rights, has incorporated a separate company to which has been transferred all of its power rights. This company will be known as the Androscoggin Water Power Co., the stock of which will be held in the treasury of the parent company. According to Julius H. Barnes, chairman of the board of directors of the Pejepscot Co., the importance of the water power rights during recent years has greatly increased and the question of supplying some of the New England industries with power from these sources has become one of much importance on regulated streams such as the Androscoggin, hence it is deemed advisable, before any development of water power for other than its own consumption shall take place, that a separate company be organized to handle such matters.

FOLLOWING THE RECENT purchase of the plant and property of the Chesterland Light & Power Co., Chesterland, Ohio, the Cleveland Electric Illuminating Co., Cleveland, Ohio, has negotiations under way for the purchase of the municipal electric light and power plant at Chardon, Geauga County, and the plant and system of the West Claridon Light & Power Co., operating in this same district. The purchasing company plans for extensions in transmission lines for light and power service in the different communities, including local substations for this purpose.

At Lehigh University, Bethlehem, Pa., an interesting departure in engineering training is being undertaken, i.e. a course in Industrial Engineering. This will be an undertaking to give engineering students as thorough a grounding in the fundamentals of business—finance, accounting and forecasting of economic developments—as in mathematics and science. It is intended to train for executive work in technical industries, rather than for strictly engineering design and construction. The course will lead to a degree of B. S. in Industrial Engineering. Further information can be had from C. M. McConn, Dean, Lehigh University, Bethlehem, Pa.

Catalog Notes

Ash hoists as made by Herbert Morris, Inc., Buffalo, N. Y., are described and illustrated in a catalog recently issued by that company.

Bulletin No. 625, recently issued by The Esterline-Angus Co., of Indianapolis, Ind., describes graphic pressure recorders and their uses.

Standardized Steel tower outdoor substations, intended for installation by utilities serving customers buying power from high tension distribution lines, are described in Bulletin No. 12, recently issued by the Delta-Star Electric Co., Chicago, Ill.

M. B. Skinner Co. in a recently issued rotogravure folder shows in an interesting way its line of appliances for keeping valves and bibb cocks in order and for stopping leaks in pipe lines. A copy may be had from the Skinner Co. by writing to 558 Washington Blvd., Chicago.

Bulletin No. 6, recently issued by the Atlas Valve Co., Newark, N. J., is devoted exclusively to the Victor temperature regulator and contains about all of the information that one may desire relative to the installation, operation and application of the Victor line of hydraulically operated temperature regulating devices.

"The Jones Side Dump Stoker" is the subject of publication No. 90, recently issued by the Riley Stoker Corp., of Worcester, Mass. The catalog contains 20 pages, which are well illustrated with halftones of photographs and wash drawings, as well as line illustrations, which give a clear conception of the construction and operation of the Jones stoker.

"What Boiler and Why" is the title of Bulletin No. 11, recently issued by The Wickes Boiler Co., of Saginaw, Mich. This is printed in folder form and gives the various advantages of the horizontal cross drum boiler, which is manufactured by this company. It also contains photographs, line drawings and wash drawings, illustrating the features of this boiler.

Barrett, Haentjens & Co., Hazleton, Pa., has issued a 24-page bulletin entitled "The Automatic Operation of Centrifugal Pumps." The publication describes methods used to make centrifugal pumps start, stop and run without constant attention and shows how various automatic control devices can be used to insure protection against damage to the pump due to loss of water, suction air leaks and other operating difficulties.

Power Plant Equipment, manufactured by the Swartwout Co., Cleveland, Ohio, is described in a new 64-page catalog, which contains accurate data and dimensions, covering particularly feed-water heaters and wrought steel separators.

"Seamless Metal Hose," manufactured by Chas. Cory & Son, Inc., New York City, is the title of Bulletin 201-29-A, which has recently been issued. The bulletin illustrates and describes the various types of metal hose manufactured by this company and gives a table of dimensions, weights, pressures and bending radii.

The L. J. Wing Mfg. Co. has just issued a new 32-page bulletin, No. 77, on its turbine blowers. This bulletin is considerably larger than the previous one, containing much new and interesting information, including data relative to the application of these blowers to stokers and graphical representation of their use for hand-fired boilers.

Detroit Underfeed Stokers of the single retort type are described in a new 32-page bulletin just published by the Detroit Stoker Co., Detroit, Mich. Among other items of outstanding interest to combustion engineers, the bulletin contains a number of fuel bed cross sections showing conditions of the fire with respect to air distribution and movement toward the dumps.

Combustion Engineering Corporation of New York has just issued a catalog on its air heater. The primary use for this product is the pre-heating of air to be used in boiler furnaces, by means of the heat that is ordinarily wasted in flue gases. This catalog is available to those who request it.

The pre-heating of air for combustion has been adopted in this country only within the last 3 or 4 yr., but the large economies to be derived from this practice are now so generally recognized that most of the new power stations and many existing plants are installing air heaters.

Three new bulletins have just been issued by the Pennsylvania Pump and Compressor Co., of Easton, Pa. Bulletin No. 122 deals with aftercoolers; No. 123 describes and illustrates straight line, single stage, double acting types of air compressors and vacuum pumps; No. 124 gives consideration to the Pennsy-portable air compressor. In addition to detailed descriptions of the equipment, these bulletins contain tables giving dimensions and capacities of compressors and other data of interest to engineers dealing with compressed air.

In the third edition of "Standards of The Hydraulic Society" which has just been issued, is found not only the information embraced in the earlier editions, but also much new and valuable data, such as a standard classification of pumps; standard nomenclature and definitions pertaining to the industry; standard dimensions for cast-iron flanges and cast-iron flanged reducers for 125 lb. and 250 lb. steam pressures as adopted by the A.S.M.E.; and a complete list of chemicals and other special liquids, specifying the materials recommended in the construction of pumps for handling these special liquids. Copies of the booklet may be obtained from any pump manufacturer who is a member of The Hydraulic Society, or upon application to C. H. Rohrbach, secretary, 90 West St., New York.

The Flexible Steel Lacing Co., of Chicago, is distributing a folder announcing a new size of belt fastener intended for use on belts from ¼ to 7/16 in. thick on both conveyor and heavy duty power transmission service.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Geared to Power Plant Progress

A feast of facts and a flow of information which will be published in the last three regular issues of 1925 and the first three issues of 1926, are being prepared for the readers of Power Plant Engineering.

Two great power shows, engineering progress in 1925 to be reviewed, and advances in boiler plant operation require the enlarged editorial service to be given in these Six Feature Numbers.

Every engineer should get all he can out of the Fourth Annual Exhibition of Power and Mechanical Engineering to be held at Grand Central Palace, New York, Nov. 30 to Dec. 5 next.

Attend this show if it is possible for you to do so. See the particular exhibits that are most helpful to your plant and work. Select the talks and motion pictures most valuable to you.

This year's New York Power Show has every indication of being greater than ever. With the many attractions and the large attendance which may be expected, it is necessary to be informed beforehand to take full advantage of the limited time at the show.

November 15 Power Plant Engineering will be the Announcement Number of the New York Power Show. In it you will find a list of the exhibitors with location and chief features of their exhibits and plans of floors of the exhibit hall.

Use it as the catalogue of the great educational program offered at the show. From it plan what to see and hear.

Those unable to attend will find that its editorial and advertising pages will enable them to keep informed on the outstanding developments in the machinery, equipment and supplies to be exhibited at the show and the topics to be discussed at the meetings.

On Dec. 1 you will receive the New York Power Show Number which will give a list of representatives of exhibitors and detailed program of talks and motion pictures.

This number will be distributed from Power Plant Engineering's booth at the show, to which you are invited.

A valuable guide while attending the show, and an issue to preserve with the preceding one to visualize permanently this great exhibition.

What now seems to be the year of surpassing progress in the power plant field will be epitomized in the Dec. 15 Annual Review Number.

Articles on pulverized fuel practice, feed water deaeration and evaporation, interconnection of systems, mercury turbine, rural supply and high head water turbines are among those you will find in this number.

The advertising pages will give information on the machinery, equipment and supplies available to bring plants up to higher standards of economy and progress.

The boiler plant has been called the heart of power generation, and certainly there is where the greatest opportunities for achievement seem to center.

The Jan. 1, 1925, Boiler Plant Operation Number will cover operating methods in the boiler room; firing; combustion control; feed water treating and control; boiler and furnace upkeep; economizer operation; pump operation, and ash removal.

This January 1st issue will be the 18th of Power Plant Engineering's Annual Reference and Textbook Numbers, and no effort is being spared to make its editorial pages of utmost helpfulness.

As in former specialized issues, the reader will find the advertisements of the leading manufacturers in the field which, as in past years, will comprise a valuable reference guide to the purchase of everything used in modern plants.

January 26 to 30, 1926, is the date of the Chicago Power Show. Exhibits, regional meetings and direct contact with leaders in the field will make attendance at this show a pleasure and duty to progressive power plant men.

There will be so much to see and hear at the New York and Chicago shows that many will attend both, while to men from the West, South and Middle West, the Chicago Show will be a real boon.

Advance information will be given in the Jan. 15 Announcement Number on the Chicago Power Show. In it you will find layout of the exhibition hall, list of manufacturers with location and nature of their exhibits, from which you can plan your visit at the show to best advantage.

Make your headquarters at Power Plant Engineering's exhibit booth at the Chicago Power Show. Here you will find the Feb. 1 Chicago Power Show Number with list of representatives, arrangements for exhibitors and visitors, location of exhibits, program of lectures and regional meetings of A.S.M.E. and other engineering societies.

The Feb. 1 issue will bring the show to all subscribers as nearly as possible and will be valuable for reference.

Facing the splendid opportunities that every branch of power plant engineering holds forth at this time, these Six Feature Numbers should be followed with great interest and filed for ready reference.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allen & Billmyre, Inc., New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR FILTERS.
Allen & Billmyre, Inc., New York.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Lavino & Co., E. J., Philadelphia.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.
Hagan Co., George J., Pittsburgh.
United Conveyor Corp., Chicago.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyor Corp., Chicago.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH TANKS.
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.
United Conveyor Corp., Chicago.

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.
Flexible Steel Lacing Co., Chicago.

BELTING.
New York Belting & P'k'g Co., New York.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 154

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Allen & Billmyre, Inc., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N.Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Allen & Billmyre, Inc., New York.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
McLeod & Henry Co., Troy, N.Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills, McCanna Co., Chicago, Ill.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Lavino & Co., E. J., Philadelphia
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Condenser Cleaner Mfg. Co., Pittsburgh.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw,

BOOKS AND SCHOOLS.
Sweet's Catalogue Service, Inc., New York, N. Y.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, O.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
McLeod & Henry Co., Troy, N. Y.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The Hartford, Conn.
Sherwood Mfg. Co, Buffalo,

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.